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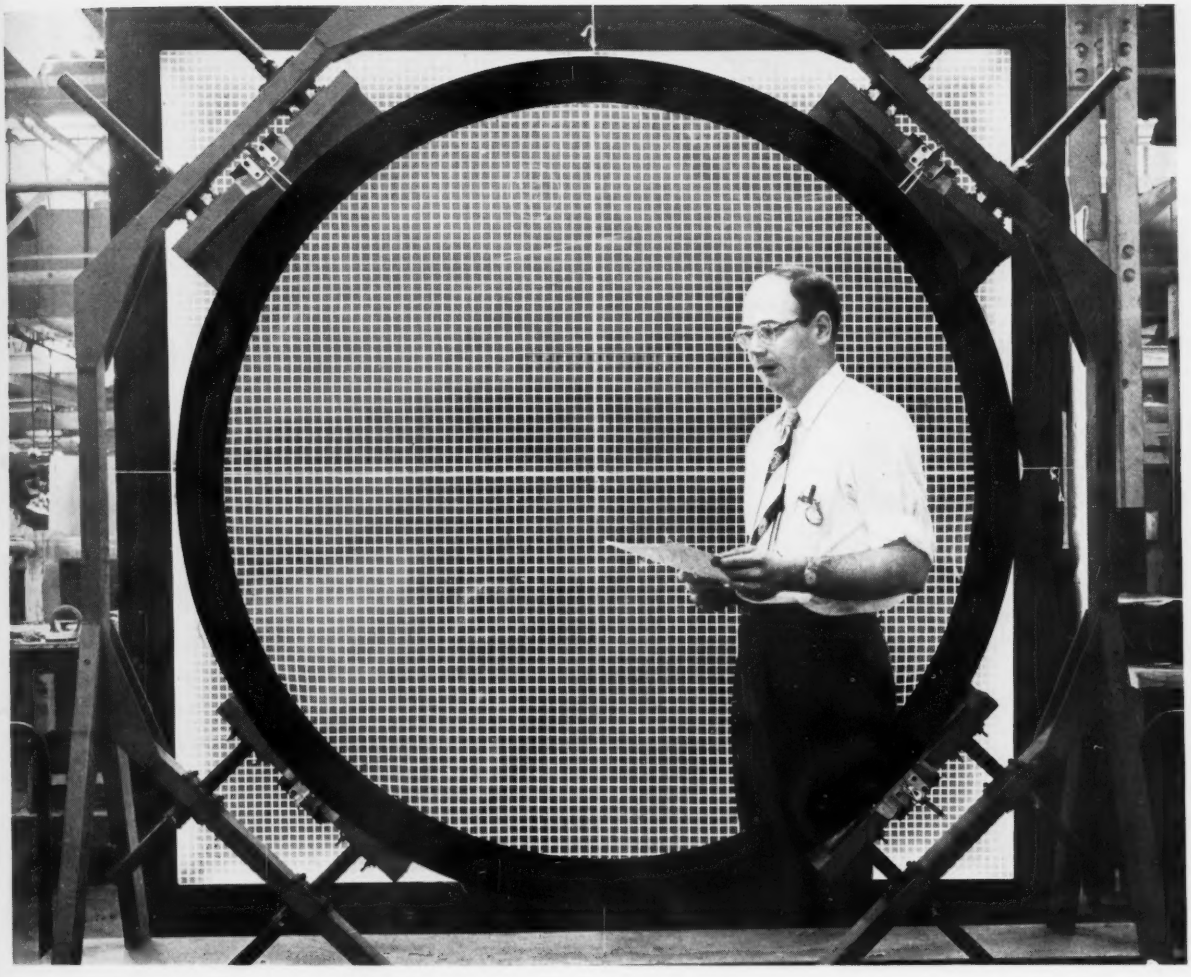

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Cover—An improved version of Goodyear Aircraft Corporation's rubber Inflatoplane, built for the Office of Naval Research, is powered by a 44-hp. Nelson engine. The plane's wing, tail assembly, and cockpit are made of Airmat (two walls of rubberized fabric connected by nylon threads). The cigar-shaped fuselage also is made of rubberized fabric. Test Pilot Dick Ulm is giving the signal for Development Engineer John Phillips to fire the engine.

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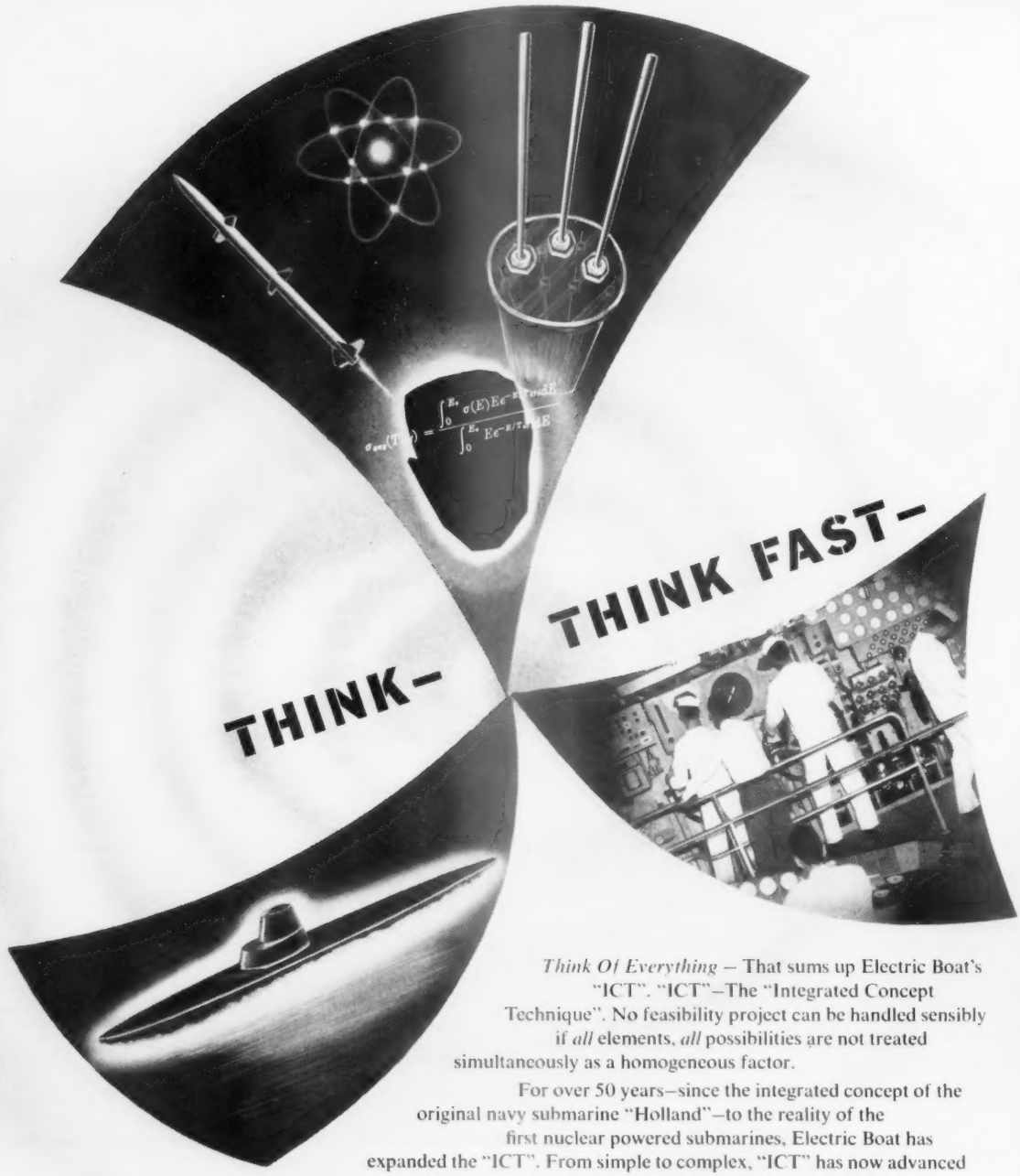

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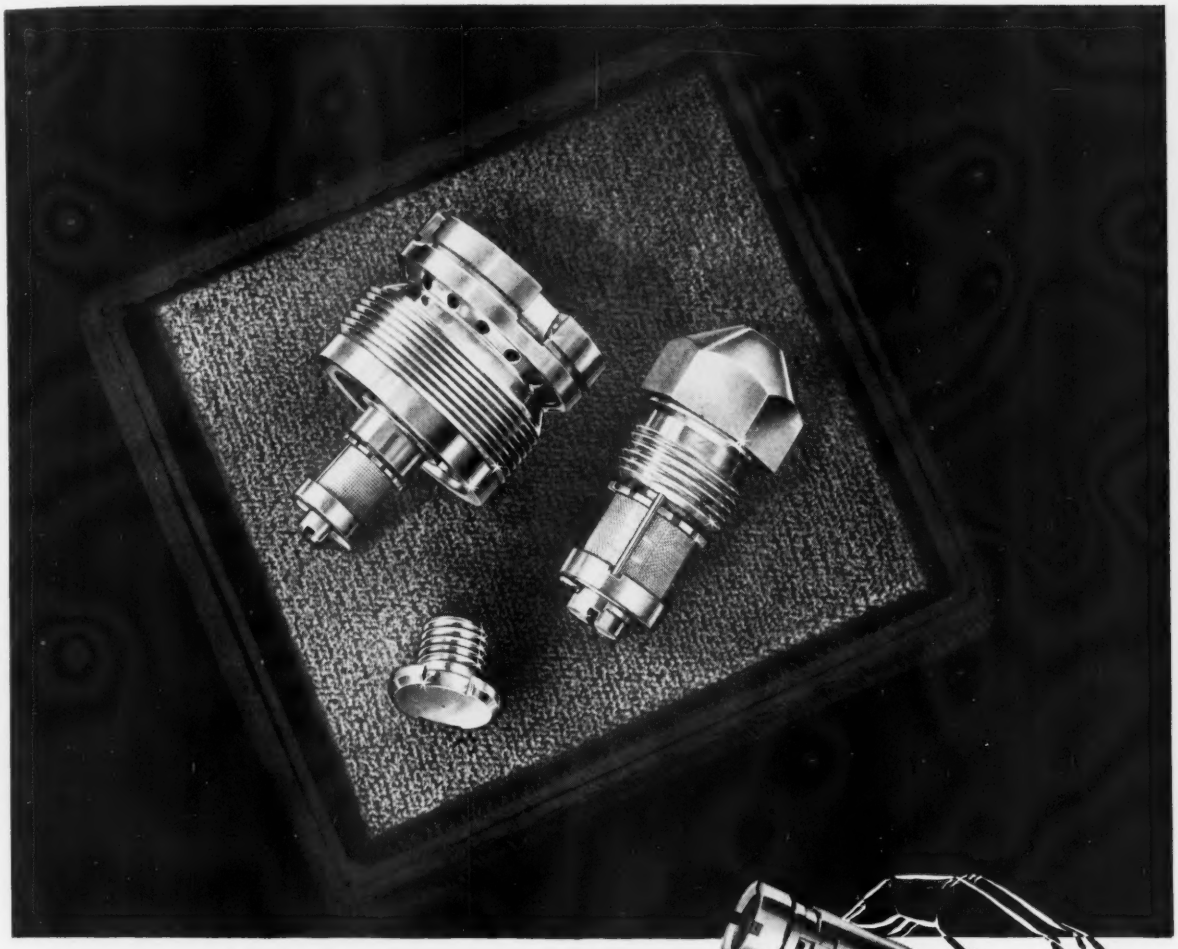

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Semi-conductor work is but one facet of an integrated program in solid state physics. Studies of chemical, mechanical and surface properties of solid crystals and "sputtering" of metals under ion bombardment are among several other areas presently being researched in the Electron Physics Laboratory.

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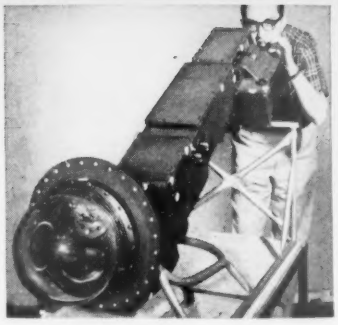

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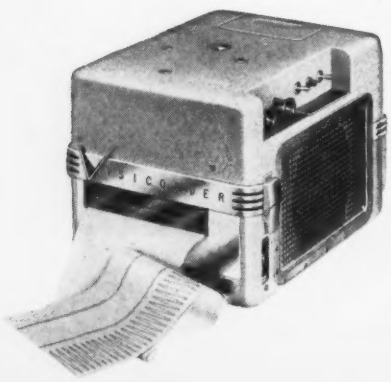

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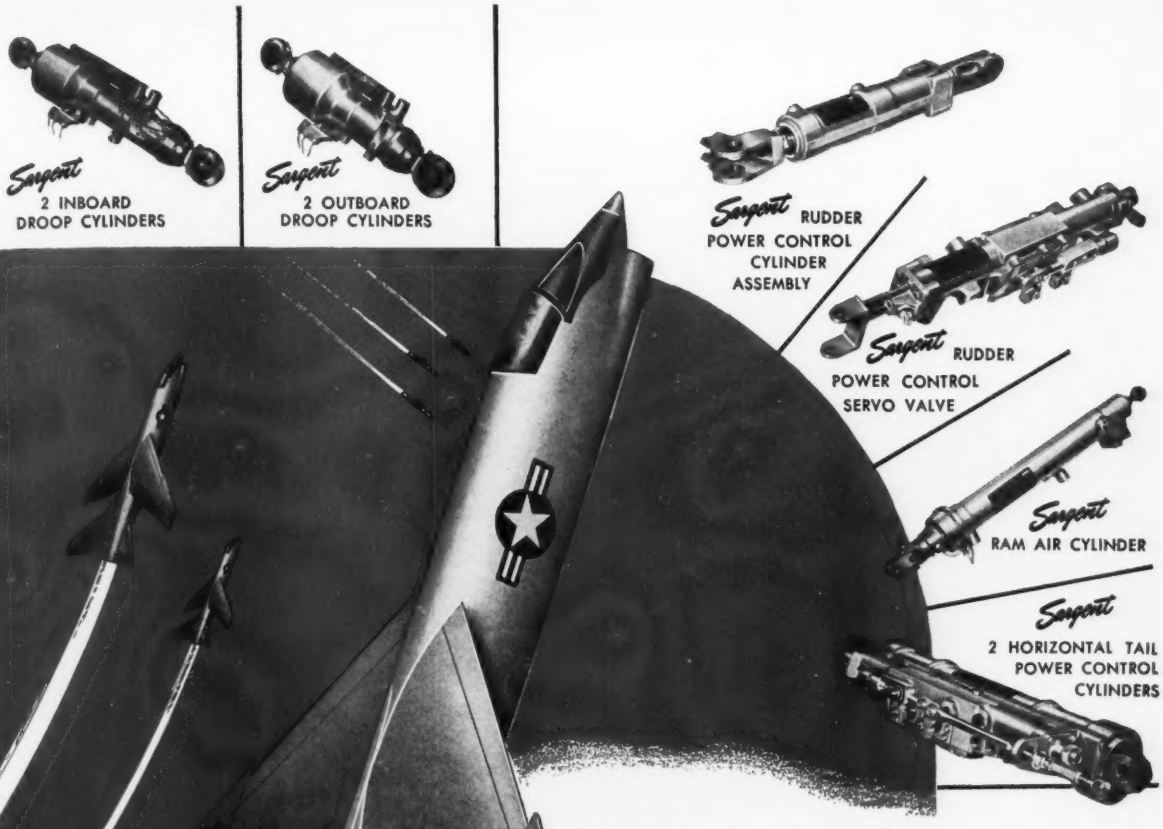

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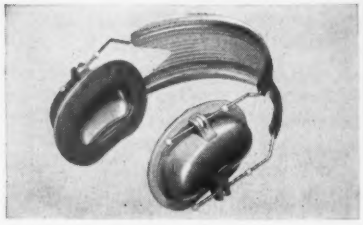

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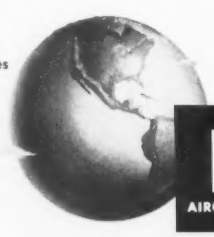

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SPECIFICATIONS FOR TYPE D-822

Normal operating load: 26,000 inch-pounds
Maximum operating load: 52,000 inch-pounds
Ultimate static load: 75,000 inch-pounds
Travel: 45 degrees at .625 RPM
Amperes: 4 amps. at 26,000 inch-pounds at 480 cycles on 200 volts
Weight: 35 pounds
Qualification: Type D-822 has been designed and qualified to meet applicable military and aircraft manufacturers' specifications.

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DESIGNERS AND PRODUCERS OF MOTORS, LINEAR AND ROTARY ACTUATORS . . . EXCLUSIVELY!

3-548

E.D.O.S.

... A. O. Smith's proven method for fabricating aircraft that will

smash
the thermal barrier

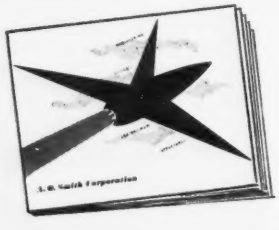
✳ E. D. O. S. means Engineered Designs for Optimum Structures . . . offers significant savings in fabrication of hard, heat-resistant alloys.

BACK when airframe construction first switched from wood and fabric to light metals — the thin alloy skins were actually sewn together with piano wire. Manufacturing methods had not kept pace with materials development.

Today, with supersonic aircraft nudging the thermal barrier, there's another big switch underway . . . a change to heat-resistant, high-strength alloys (steel, titanium, stainless).

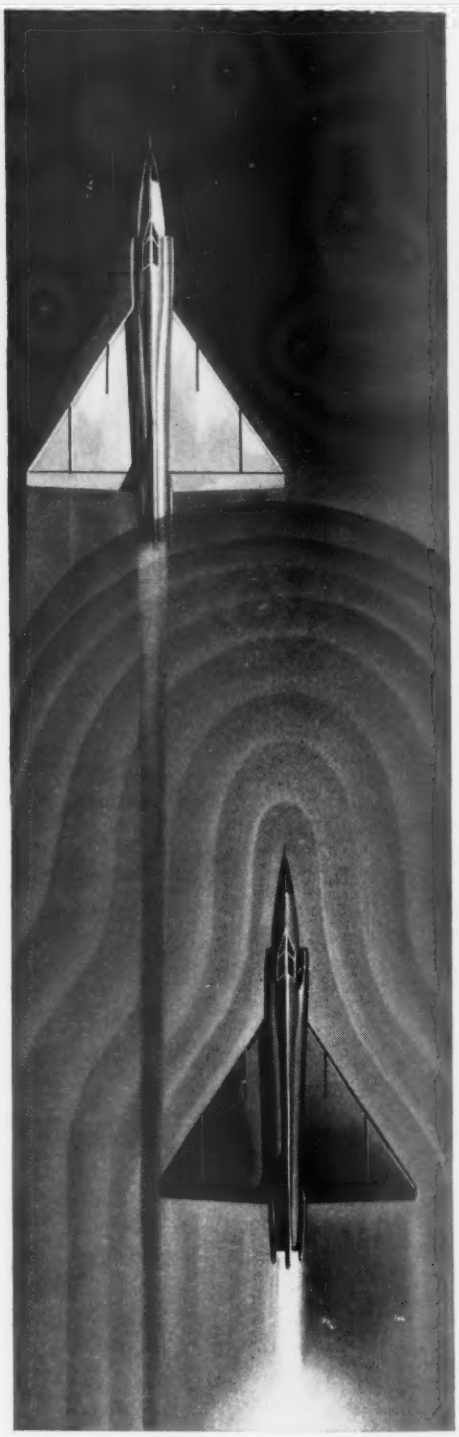
This time, however, there's no need to compromise with light metal methods in hard metal fabrication. No need for extensive, time-consuming machining...no need to turn costly alloys into scrap.

The answer is A. O. Smith's E.D.O.S. — redistribution of metal for maximum usefulness. Proved in the manufacture of jet engine parts and other aircraft components — the method consists of precision forging, contour rolling, flash and fusion welding. It's made to order for tough metals . . . produces a lighter, stronger product at lower cost than any other existing process.



WRITE A. O. SMITH TODAY FOR FREE, ILLUSTRATED BOOKLET

— Bulletin I-17A — complete with technical details. Also, arrange for showing of new 16-mm. sound color movie about this remarkable process.



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A.O.Smith
CORPORATION
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International Division: Milwaukee 1, Wisconsin

Deadliest fighter plane gets instantaneous control at all altitudes with

HYCO-SPAN CONTROL CABLES

The Convair F-102A supersonic Air Force interceptor can streak into the stratosphere and hunt down an enemy bomber in any kind of weather, day or night. It is packed with the latest electronic gear that locates the target at long range, directs the pilot on the correct attack course, and automatically fires the guided missiles or rockets at the proper instant.

To obtain the most accurate flight control, American Hyco-Span Control Cables were used. These more nearly match the expansion and contraction of aluminum alloy air frames than any other type of control cable. They have a 50% higher coefficient of expansion than the best carbon steel cable . . . one third higher than the best stainless steel cable. As a result, Hyco-Span Cables give you smooth positive control at 70°F *below* zero or 70°F *above*—and without needless extra weight.

Other important advantages of Hyco-Span Cables

1. **Non-magnetic** – do not affect accuracy of sensitive electronic instruments.
2. **Long life** because of excellent corrosion resistance, and low coefficient of friction which permits low cable tension.

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Please send me, without obligation, a copy of your booklet, "Hyco-Span Aircraft Cable," which describes all the important advantages of this control cable.

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UNITED STATES STEEL

Successful Installations

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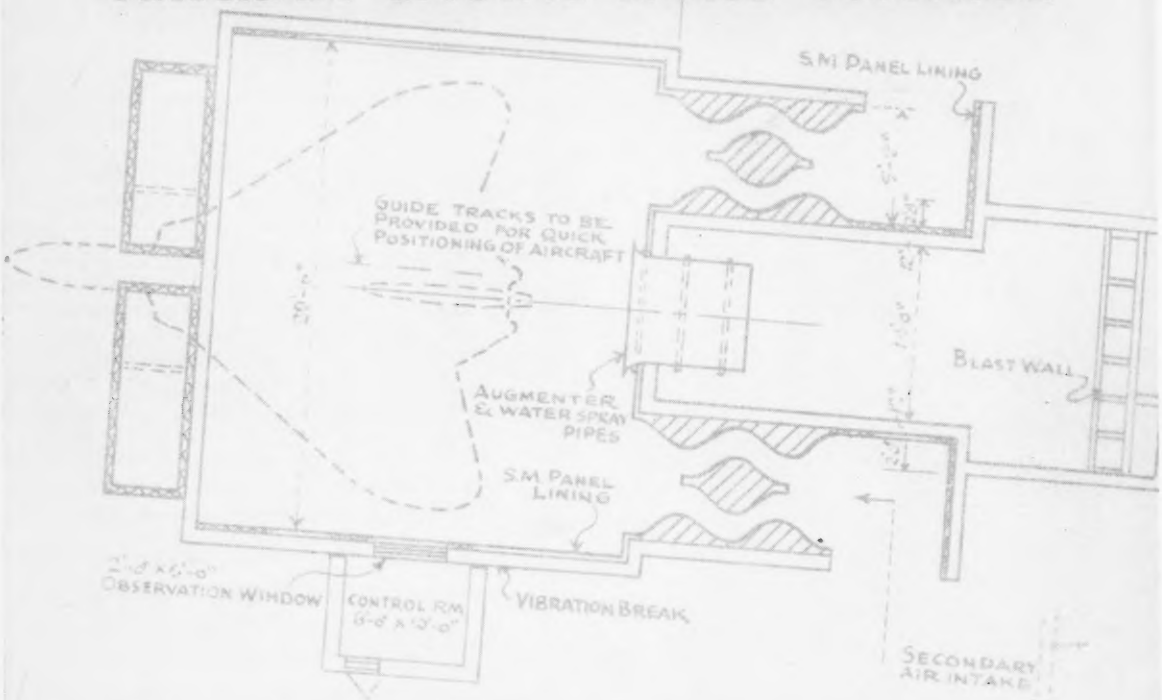

Finest Engineering Service. Complete Line of Equipment. Unmatched Experience.

Koppers Industrial Sound Control's experience, engineering, equipment and number of successful installations stand unchallenged in the suppression of sound for the aircraft industry.

Koppers Industrial Sound Control engineers have silenced aircraft engines of all types, in "hush houses" and with portable run-up mufflers. They have pioneered in the design of sound control equipment to solve the specific problems found in the aircraft industry. Koppers provides complete engineering service . . . including the handling of construction details for entire buildings.

Koppers Industrial Sound Control equipment is now at work suppressing noises for the aircraft industry, for other industries and in air conditioning systems. If you have a sound control problem of any kind, your wisest move is to write KOPPERS COMPANY, INC., Industrial Sound Control Dept., 5908 Scott Street, Baltimore 3, Maryland.

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INDUSTRIAL SOUND CONTROL

Koppers Company, Inc., Metal Products Division
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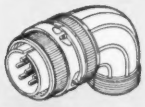
Engineered* Products Sold with *Service

connect with CANNON PLUGS

for better electrical and electronic equipment

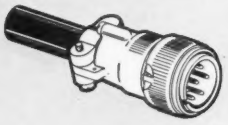
USE for AIRCRAFT and ELECTRONIC INSTRUMENTS

TYPICAL DESIGNS



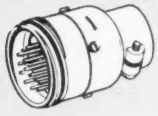
AN, AN-A, AN-B, AN-C...Conforming to Specification MIL-C-5015C. 15 insert diameters and 260 contact layouts. 6 shell styles, AN3100 to AN3108 with all accessories. Also (AN) F, O(*)AF.

for VIBRATION RESISTANCE and MOISTURE-PROOF applications



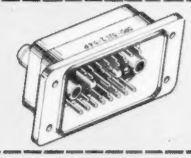
AN-E SERIES ... environment resisting. Replaces AN-M. Meets Specification MIL-C-5015C. Resilient inserts. Integral cable clamp. New grounding lugs. Interfacial sealing, improved grommet and new grommet follower.

for GENERAL CIRCUITRY and QUICK DISCONNECT in more rugged applications



K, RK SERIES... **SPECIAL ACME THREAD.** The All-Purpose Series. Conduit and cable clamp entry types. 1 to 82 contacts in 213 different contact layouts. 10-, 15-, 30-, 40-, 60-, 80-, 115-, and 200-amp. silver-plated contacts. High quality phenolic, melamine, and formica insulators. Cadmium-plated aluminum alloy shells.

for UNIT-PLUG-IN applications...

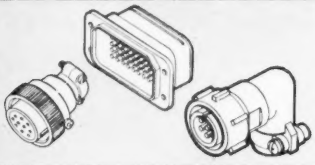


DP, DPB, DPD, DPD2, DPD2R, DPJ, AND DPS SERIES... Rack/panel/chassis. With and without shells; coaxial and high voltage contacts. Permit quick disconnect, interchange, replacement, testing and inspection of assemblies and sub-assemblies.

for AUDIO and LOW LEVEL circuits

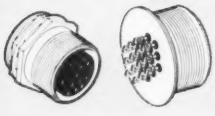
P, XLR, XL, XK, O, UA, BRS SERIES... many shell styles and insert layouts. Straight and angle 90° plugs. Latch-lock types. Wall-mounting, panel, locknut mounting, and adapter receptacles, single- and two-gang. 10- to 30-amp. contacts, coaxials. UA Series features 3 gold-plated contacts.

for RADIO and SUB-MINIATURE applications



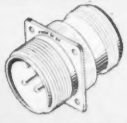
D, MC, DPA, DPX, AND K MINIATURES... miniatures and sub-miniatures designed for amplifiers, miniature indicators, computer circuits, telemetering equipment, small pre-amps, and general instrumentation where space is limited and current requirements are generally not over 5 amperes. Variety of shell styles, junction shell, and insert arrangements. 3 to 50 contacts, plus coaxials.

for HERMETICALLY SEALED applications



GS (AN TYPE), KH, RKH, DAH, BFH, TBFH, DBH, KH30... with steel shells and contacts to withstand high pressures from within or without. Insulation is a glass material, fused under high temperature to shell and contacts, thus forming a hermetic seal.

for HIGH TEMPERATURE and firewall applications



AN-K, AN-"FW," AND CANNON K-"FW" STEEL SHELL CONNECTORS... Open flame protection offered in the greatest variety of this type of connector. Wall- or box-mounting receptacles. Straight or angle 90° plugs. Crimp-type contacts. Inserts of glass-filled materials.

Send for AR Condensed Catalog containing illustrations and technical information on all principal series of connectors in the extensive Cannon Line.

CANNON ELECTRIC COMPANY, 3208 Humboldt St., Los Angeles 31, California. Factories in Los Angeles, Salem, Mass., Toronto, Can., London, Eng., Melbourne, Austl. Manufacturing licensees Paris, Tokyo. Representatives and distributors in all principal cities.

please refer to Dept. 105

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Since 1915

X-ray inspection of vital aircraft landing gear parts. Westinghouse now distributes portable Balteau line.

Your problem might be solved by fluoroscopic inspection. The exclusive Westinghouse Fluorex Image Amplifier extends the field of internal inspection with fluoroscopy.

Radiographic inspection of large castings is accomplished faster with the stationary 250 KV Constant Potential Unit.

From Aircraft Parts to Giant Castings

Westinghouse Industrial X-ray Equipment Can Handle Any X-ray Inspection Problem—From Aircraft to Giant Castings

Now – with transportable units, stationary units up to 250 KV capacity, production line units and versatile fluoroscopic units including image amplification, Westinghouse solves your most difficult internal inspection problems.

If you feel that our staff of Industrial X-ray Engineers can assist you in any way, please write: Westinghouse Electric Corporation, X-ray Department, 2519 Wilkens Avenue, Baltimore 3, Maryland.

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X-RAY DEPARTMENT

Westinghouse Electric Corporation

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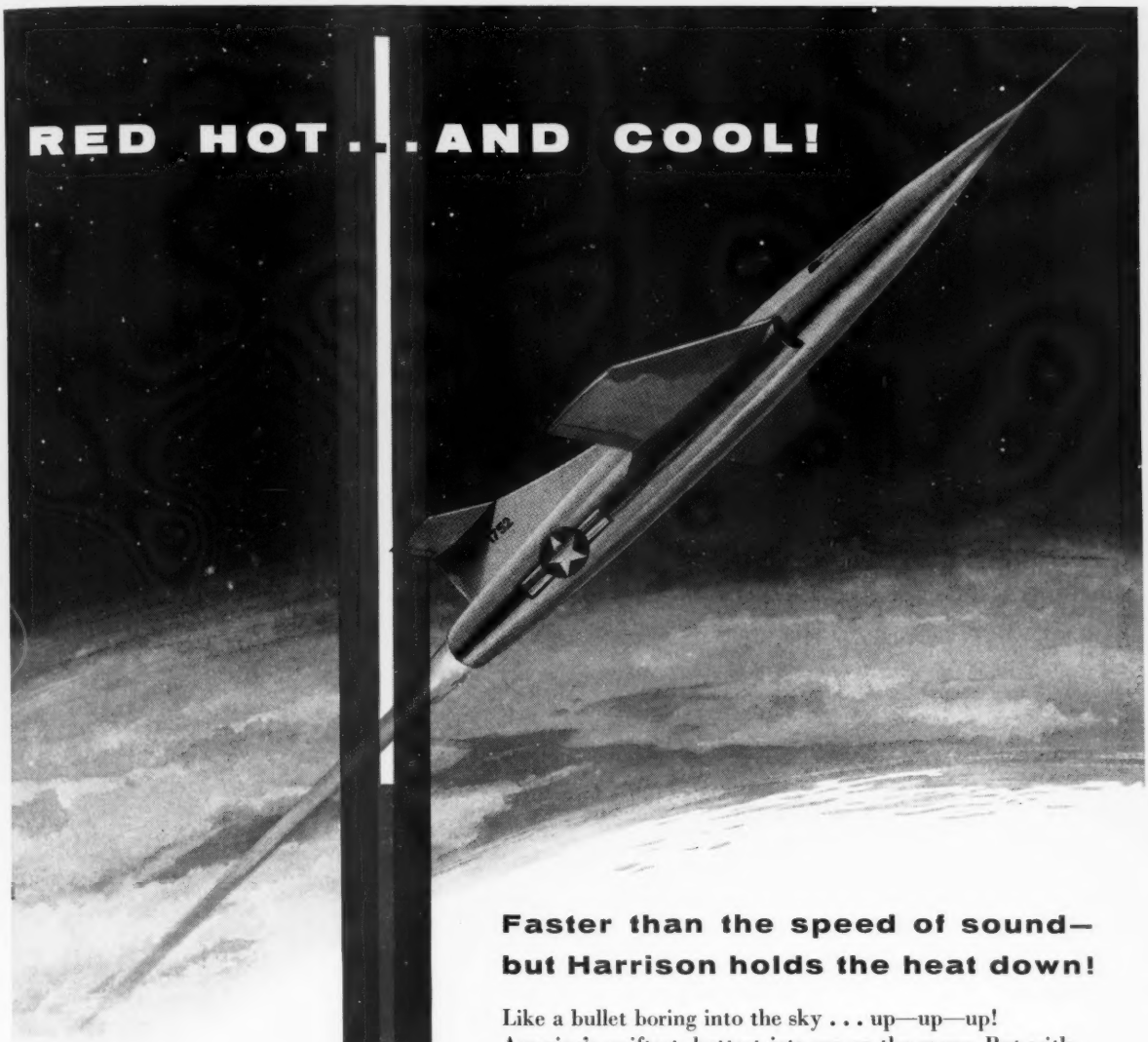
J-08333

RED HOT . . . AND COOL!

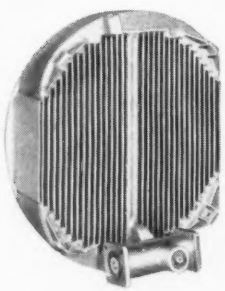


Faster than the speed of sound— but Harrison holds the heat down!

Like a bullet boring into the sky . . . up—up—up! America's swiftest, hottest jets are on the move. But with Harrison heat exchangers on the job, engines are running cool—temperatures are under control. In fact, you'll find lightweight, heavy-duty Harrison coolers on the job in just about every type of modern aircraft. Design of special cooling equipment for the world's finest, fastest jets is another example of Harrison leadership in temperature control. Long experience and extensive research facilities mean that Harrison is ready and able to meet the cooling demands of the Jet Age. If you have a cooling problem, look to Harrison for the answer.

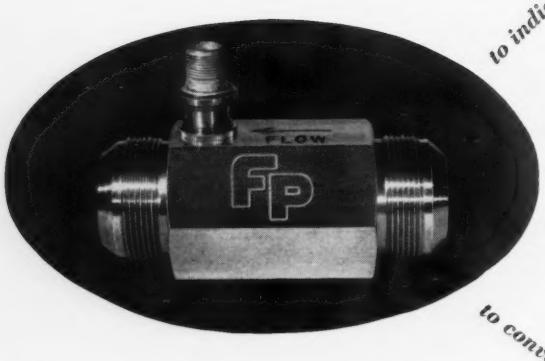
Harrison Radiator Division, General Motors Corp., Lockport, N.Y.

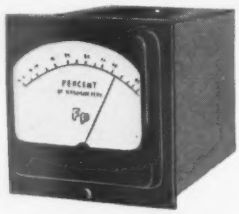
GM GENERAL MOTORS



TEMPERATURES MADE TO ORDER

HARRISON





PANEL FLOW RATE INDICATOR

to indicate flow

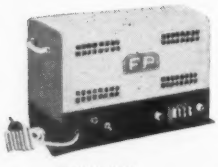
to indicate steady state flow condition

IN-LINE DIGITAL INDICATOR

to totalize flow for batch processes

DIGITAL TOTALIZER

to convert transient flow for analog output



FREQUENCY MULTIPLIER-CONVERTER

get flow information in any form you need it

. . . with F&P turbine meters and readout devices

Here's the ideal solution to flow metering problems characterized by high temperature, high pressure, high flow volume, or rapid flow transients. Fischer & Porter turbine meters are inherently among the most accurate flow measuring devices available today . . . providing measurements accurate to ½% of instantaneous rates.

The low inertia, axially balanced rotor of the F&P turbine meter gives optimum response to rapidly changing flow rates . . . providing positive information on changes as soon as they *begin*, not after they happen. A basic frequency output, directly proportional to flow, provides a common language easily fed to indicating, recording, or transmitting equipment. You can have digital or analog indication . . . oscilloscope recording . . . circular or strip chart recording . . . digital totalizing . . . transmission or any combination of these. Here are just a few of the Fischer & Porter output devices you can dovetail with one or more turbine meters:

PANEL FLOW RATE INDICATOR: Provides scale reading in desired flow units or in percentage of maximum flow. Includes amplifier which may be used to feed EPUT meters or integrators, and analog converter.

"IN-LINE" DIGITAL INDICATOR: Direct digital readout of flow information in desired gravimetric or volumetric units. Automatically selects turbine meter outputs by flow range.

DIGITAL TOTALIZER: Provides integrated flow information accurate to ½%.

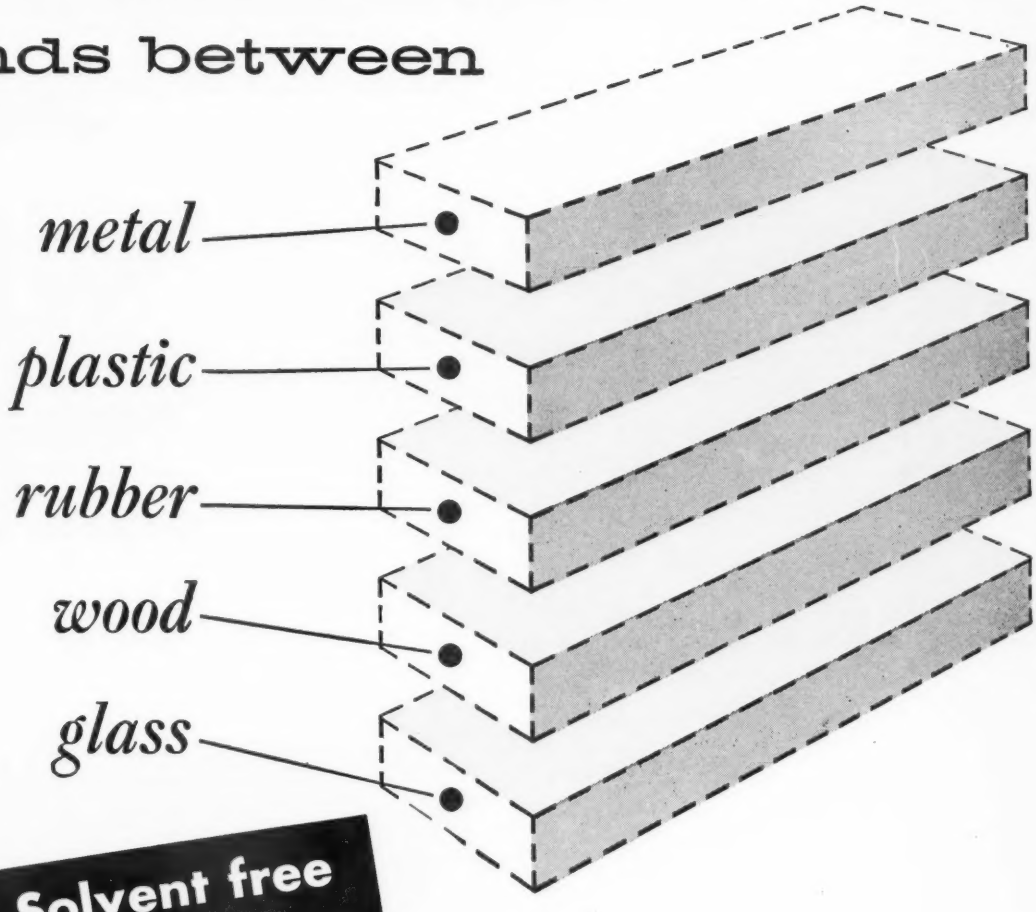
FREQUENCY MULTIPLIER-CONVERTER: Extremely rapid response to transient flow signals. Sampling of eight points per cycle provides more information than conventional means.

For complete data on the F&P turbine meter and some of the systems it makes possible, write for catalog. Address request to Fischer & Porter Co., 1947 County Line Road, Hatboro, Penna.

FISCHER & PORTER CO.

Complete Process Instrumentation

For high-strength bonds between



Solvent free®

EPON ADHESIVES

permit instant assembly of components

Because of its remarkably high strength and resistance to vibration, Epon adhesive bonding is replacing expensive welding and riveting operations in many aircraft applications.

Because they contain no solvents, Epon adhesives permit immediate assembly of nonporous parts. Contact pressure alone is all that is required to form sound, strong bonds. Surfaces need not be machine-finished before bonding, and glue lines need not be uniform. Air-relief drilling is never required.

For your specific needs, two standard formulations are:

EPON ADHESIVE VI: General purpose, high-strength adhesive will cure at room temperature or slightly above.

EPON ADHESIVE VIII: High strength, capable of withstanding moderately high service temperatures. Will cure in 90 minutes at 200° F.

Epon adhesives have been used successfully in bonding metal, plastics, rubber and wood for bomb-bay doors, jet fuel tanks, structural joints, honeycomb wing sections, primary aircraft structure, and other aircraft applications. Can Epon adhesives solve an assembly problem for you? Write us about your problem and we'll send information and samples.

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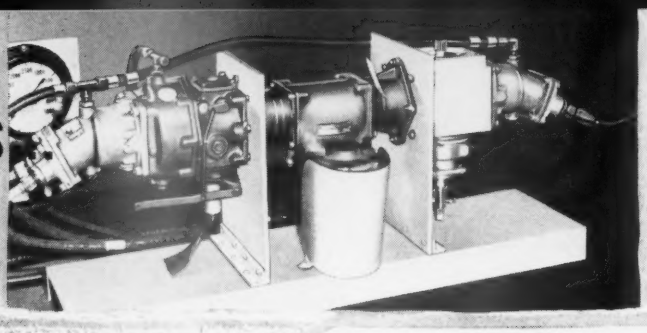
SHELL

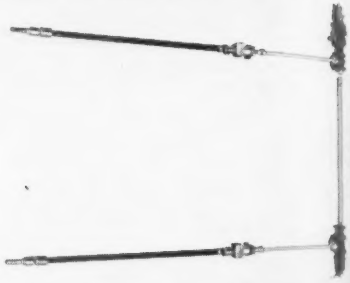
These are units...

(by Western Gear)

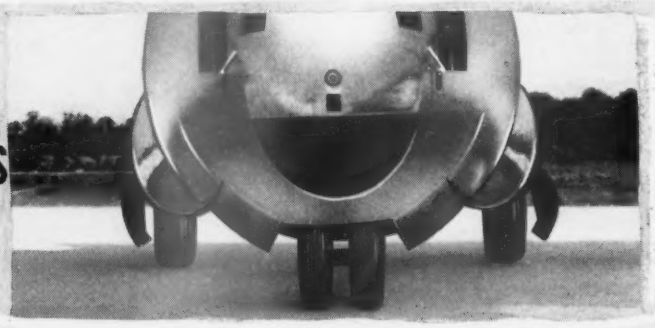


that are part of the system...

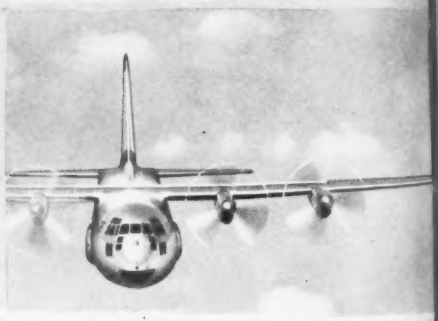
(also by Western Gear)



that lowers the wheels



on the plane that Lockheed built



. . . fastest U.S. Air Force transport in production, can be sure of dependable performance from the landing gear actuating system. This system and other Western Gear products aboard this aircraft including motors, gear boxes, shafts and actuators have been tested in Western Gear's block-long laboratory to insure dependable operation under every conceivable condition of flight. Western Gear believes in its slogan, "The difference is reliability." Its products prove it.

There's a Western Gear aircraft specialist immediately available to help solve your mechanical power transmission problem. Call on him now. He'll be glad to help. Address General Offices, Western Gear, P.O. Box 182, Lynwood, California.

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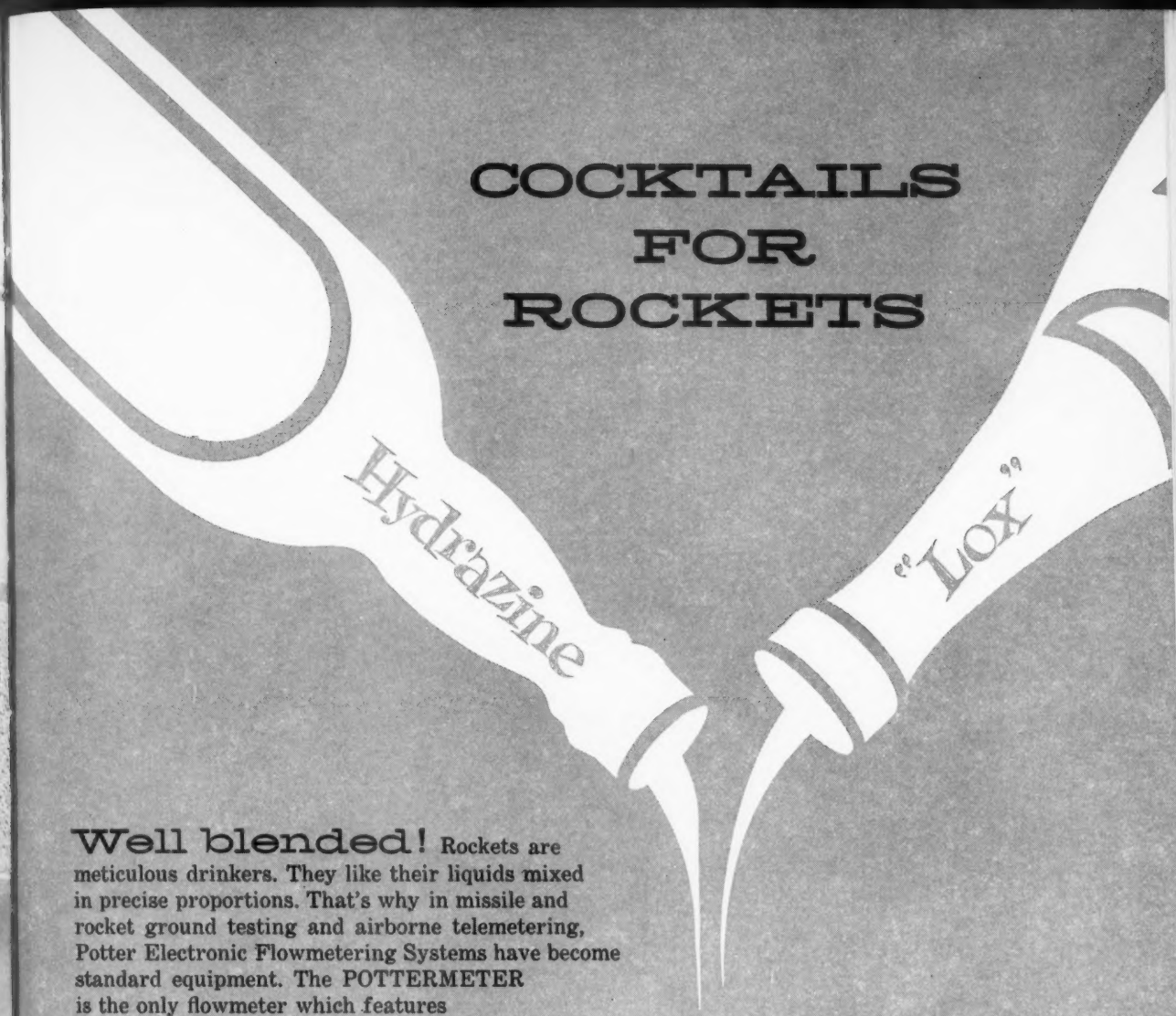
ENGINEERS AND MANUFACTURERS

PLANTS AT LYNWOOD, PASADENA, BELMONT, SAN FRANCISCO (CALIF.), SEATTLE AND HOUSTON — REPRESENTATIVES IN PRINCIPAL CITIES

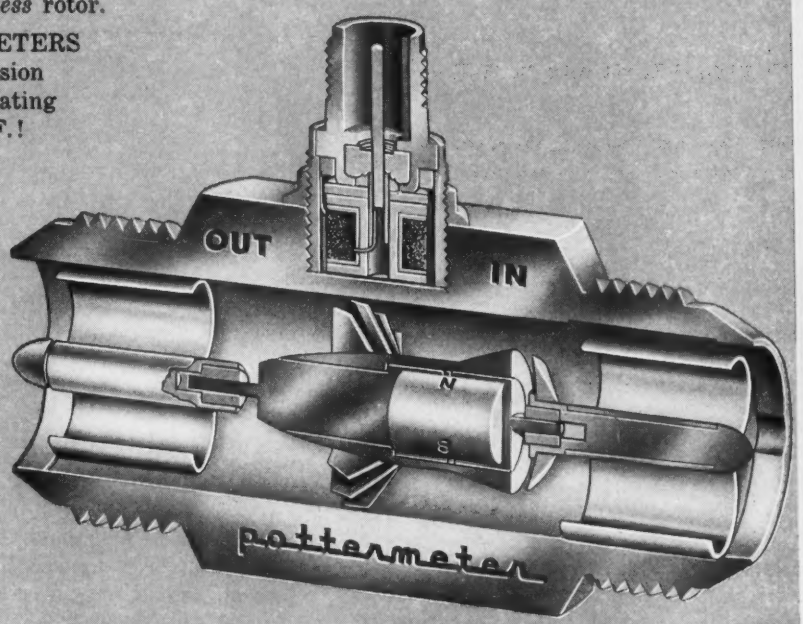
COCKTAILS FOR ROCKETS



Well blended! Rockets are meticulous drinkers. They like their liquids mixed in precise proportions. That's why in missile and rocket ground testing and airborne telemetering, Potter Electronic Flowmetering Systems have become standard equipment. The POTTERMETER is the only flowmeter which features the hydraulically positioned, *bearingless* rotor.

For more than 15 years, POTTERMETERS have been successfully used for precision measurement of continuous and pulsating flow of fluids from –455°F. to 1000°F.!

Write TODAY for Bulletin A-2



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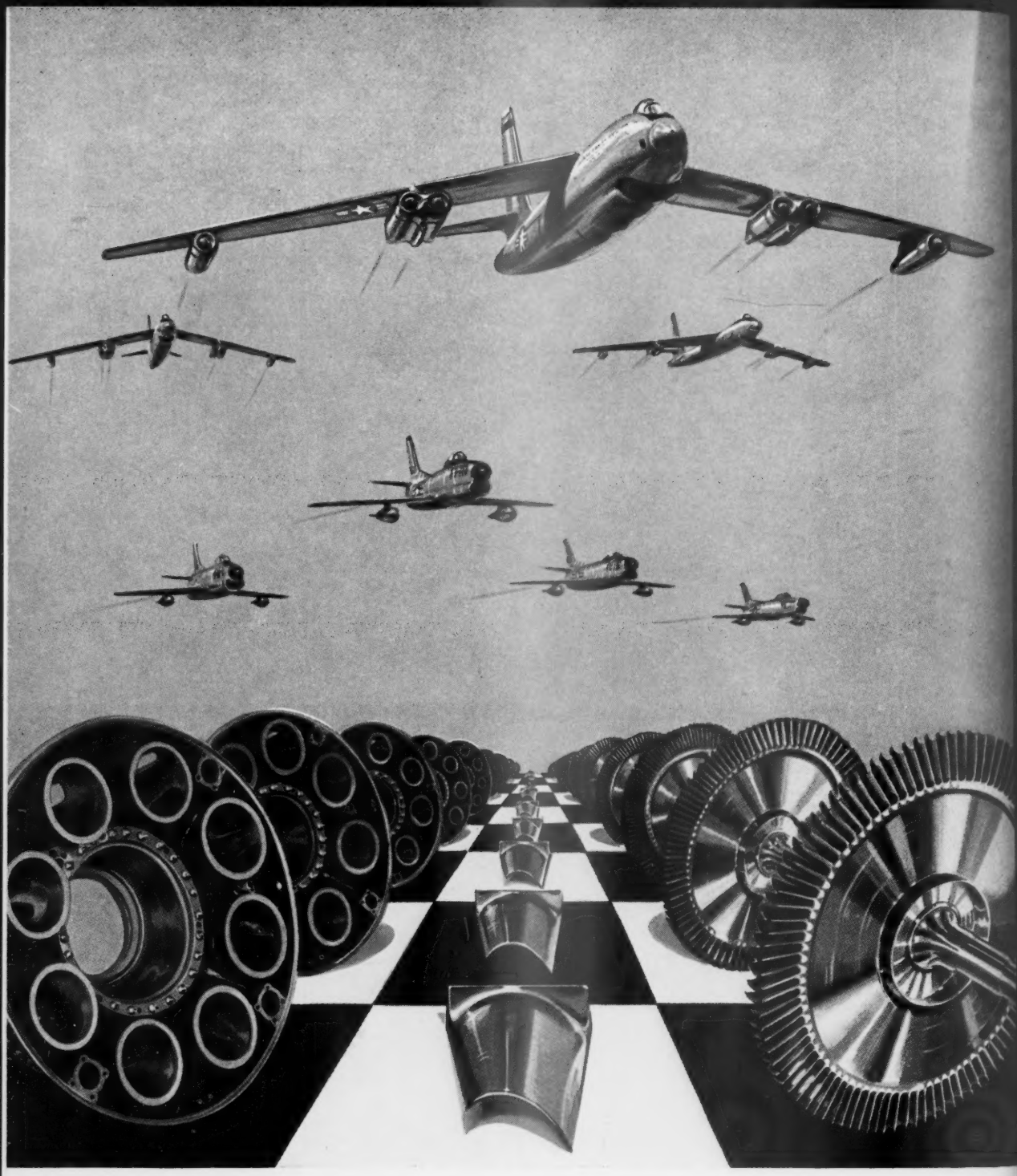
POTTER AERONAUTICAL CORP.
U. S. ROUTE #22 • Union, New Jersey • MUrdock 6-3010



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produced by Fairchild Engine Division—*in mass quantity, to highest precision standards*

Through skill, experience and production efficiency, Fairchild Engine Division manufactures such precision parts as turbine wheels, frames, diaphragms and turbine buckets for the jet engines of some of America's most powerful fighters and bombers. Subcontracting many other parts as well, Fairchild Engine Division has proved dependable production performance in mass quantity to highest precision standards.

Now in Fairchild's new plant at Deer Park, Long Island, this production capability is increased even more, and will be put to work wherever necessary to serve today's ever expanding aviation industry.

FAIRCHILD

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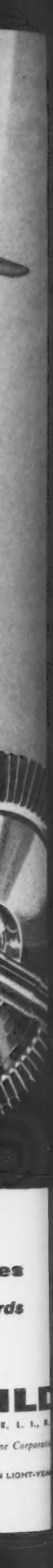
A Division of Fairchild Engine and Airplane Corporation

...WHERE THE FUTURE IS MEASURED IN LIGHT-YEA



I A S News Notes

April 1957

TENTATIVE LINE-UP for the National Summer Meeting, June 17-20, calls for 14 technical sessions, a luncheon, banquet, and a classified field trip. Two classified sessions are included: Propulsion and Development of the F-104.

NEW CORPORATE MEMBERS in the Institute fold are Shafer Bearing Division, Chain Belt Company, headquarters at Downers Grove, Illinois, and Systems Laboratories Corporation, located at 15016 Ventura Boulevard, Sherman Oaks, California.

THE INSTITUTE MOURNS: Bradley Jones (AF), Head, Aeronautical Engineering Dept., University of Cincinnati, and a pioneer in instrument development and testing, died March 8, two weeks after an acute heart attack. Pfc. Leo Abbott Leissler (TM), Inspector, Army Fontenet Ordnance Depot, Fontenet, France, died January 18. Berthin Grottland (TM), Thermodynamicist, Orenda Engines, Ltd., Malton, Ontario, Canada.

NATIONAL MEETINGS CALENDAR

6/17-20	National Summer Meeting, Biltmore Hotel, Los Angeles, Calif.
8/6-10	Naval Aviation Meeting, U. S. Grant Hotel, San Diego, Calif.
9/1-15	Sixth Anglo-American Aeronautical Conference, Royal Aeronautical Society and IAS, London and Folkestone, Gt. Britain.
10/21-22	Canadian Aeronautical Institute-IAS Meeting, Montreal, Canada.
11/7-8	Weapons System Management Meeting, Statler-Hilton Hotel, Dallas, Texas.
12/17	Wright Brothers Lecture, U.S. Chamber of Commerce Auditorium, Washington, D. C.
1/27-31	Twenty-Sixth Annual Meeting, Sheraton-Astor Hotel, New York.

JOINT MEETINGS CALENDAR

4/14-16	IRE National Symposium on Telemetering, Philadelphia, Pa.
5/13-15	IRE National Conference on Aeronautical Electronics, Dayton, Ohio. IAS Session on Cooling.
5/27-29	National Telemetering Conference, Hotel Cortez, El Paso, Texas. Sponsored by IAS, ISA, and AIEE.
6/19-21	1957 Heat Transfer and Fluid Mechanics Institute, California Institute of Technology, Pasadena, California. Cosponsored by IAS.

REGIONAL STUDENT CONFERENCES

Apr. 8	Indianapolis: Purdue University, West Lafayette, Indiana. Sponsored by Indianapolis Section of IAS.
Apr. 18-19	Southeastern: Atlanta, Georgia. North Carolina State College is host. Sponsored by Atlanta Section of IAS.
Apr. 24-26	St. Louis: St. Louis, Missouri. Sponsored by St. Louis Section.
Apr. 25-27	Texas: Fort Worth. Sponsored by Texas Section.
May 2-3	West Coast: Los Angeles. Sponsored by Los Angeles Section.
May 3-4	Middle Atlantic: University of Virginia, Charlottesville, Va.
May 7	Detroit: Wayne State University. Sponsored by Detroit Section.

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SECTION MEETINGS CALENDAR

Apr. 1	San Francisco Section: Dinner Meeting, Ramor Oaks Restaurant. (Social Hour at 6:30 p.m.) The Minta Martin Lecture, "Some Concepts and Problem Areas in Aircraft Flutter" by I. E. Garrick.
Apr. 3	Philadelphia Section: Dinner Meeting, International Airport, Skyview Dining Room, 6:30 p.m. "Air Traffic Control Today" by Leo G. Marshall.
Apr. 3	Wichita Section: Special Wives Night, Dinner Meeting, Prairie Club, 7 p.m. (Social Hour at 6:30 p.m., sponsored by Geo. E. Harris & Co.) "Operations and Maintenance Experiences Associated with the Vickers Viscount" by J. B. Franklin.
Apr. 8	Tulsa Section: Dinner Meeting, Danner's Cafeteria, 6:30 p.m. "Aerodyne" by Alexander M. Lippisch.
Apr. 8	Indianapolis Section: Dinner Meeting, Purdue University Student Union Building, 6:30 p.m. Student Paper Competition.
Apr. 16	Washington, Baltimore, and Hagerstown Sections: Joint Dinner Meeting, Hagerstown, Maryland, 7 p.m. (Social Hour at 6 p.m.) "Ultimate Objectives of Air Force Research and Development" by Courtland D. Perkins.
Apr. 17	San Antonio Section: Dinner Meeting, Dobbs House, International Airport, 7:30 p.m. (Cocktails at 6:30 p.m.) "Aeronautical Research Activities at Southwest Research Institute" by professors of the Institute.
Apr. 18	Dayton Section: Specialist Meeting, Hotel Gibbons, 6:30 p.m. "Research Objectives" and a film "The F-101 Voodoo" by A. E. Lombard, Jr.
Apr. 23	Boston Section: Joint Specialist Meeting with American Rocket Society, Massachusetts Institute of Technology, 8 p.m. "A Century of Progress in Missiles and Weapons" by Albert Clark.

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IAS News

A Record of People and Events of Interest to Institute Members

Conference on Aeronautical Electronics

IAS Schedules "Triple-Header" Session on Cooling at IRE Dayton Meeting, May 13–15

GREATER PARTICIPATION in the form of three sessions and 15 technical papers on "Cooling" will keynote the IAS contribution to this year's Institute of Radio Engineers' National Conference on Aeronautical Electronics, May 13–15, in Dayton, Ohio.

The IAS sessions will be given Tuesday morning and Wednesday morning and afternoon at the Biltmore Hotel. Frank E. Carroll, Treasurer of the Dayton Section, and Walter Robinson, Consulting Engineer, are handling the IAS arrangements.

Highlight of the 3-day conference is a forum discussion on "Wanted—New Ideas in Air-Borne Electronics" to be given Tuesday afternoon. George Haller of General Electric Company will be moderator.

Speakers lined up for the forum include Lt. Gen. T. F. Powers, USAF, Air Research and Development Command, who will speak on the future of the Air Force and its challenge to the electronics industry; John F. Arnold, Massachusetts Institute of Technology, on creative engineering thinking; Rear Adm. Rawson E. Bennett, II, Chief of Naval Research, on "Research Can Be Promoted"; Bertram D. Thomas, Director, Battelle Memorial Institute, on a subject to be announced; and H. Leslie Hoffman, President, Hoffman Radio Corporation, on the case of a large commercial research organization in creative engineering. A sixth speaker will be announced later.

Walter Robinson

Moderators of the IAS sessions will be Walter Robinson; James P. Welsh, Cornell Aeronautical Laboratory, Inc.; and Frank E. Carroll, United Aircraft Products, Inc.

Speakers and papers to be delivered at the IAS sessions are:

Tuesday, May 14—*Morning Session:* "Integration of Crew and Equipment Cooling in Supersonic Bomber Design" by A. E. Hitsman, Boeing Airplane Company; "Cooling Airflow Control Systems for Air-Borne Electronic Equipment Designed for Efficient Use of Refrigerated Air" by L. H. Schreiber and H. R. Wesson, Convair, Fort Worth; "Factors Influencing the Selection of Liquid Rather Than Air for Cooling and Air-Borne Electronic Components" by K. J. Fawcett, Melpar, Inc.; "High Reliability Thermal Designs for Commercial Avionics" by H. M. Passman, Collins Radio Company; "Crossflow Cooling of Sealed Electronic Modules" by C. D. Jones, Ohio State University.

Wednesday, May 15—*Morning Session:* "Temperature Control Design for Air-Borne Bombing and Navigation Systems AN/ASB-4" by Beal Marks, J. J. Student, R. M. Dailey, and R. W. Hook, International Business Machines, "Improved Air-Borne Equipment Design with Forced Air and Liquid Cooling" by Walter Robinson; "Heat Exchange System Design for Air-Borne Electronic Equipment" by F. T. Behning and J. P. Jacob, United Aircraft Products, Inc.; "Design of Liquid-Filled Containers for High Voltage Equipment" by T. P. Jordan, Sylvania Electric Products, Inc.; "Effects of Submerged Liquid Cooling on Electronic Performance of Several Common Types of Electronic Circuits" by K. R. Vincent and G. W. Millfat, Convair, Fort Worth. *Afternoon Session:* "Cooling and Its Applications to Infra-Red Detectors" by K. W. Harper, General Electric Company; "Methods of Determining Thermal Conditions of Electron Tubes" by J. P. Welsh, Cornell Aeronautical Laboratory; "A Method of Packaging Transistorized Printed Circuit Board Assemblies for Efficient Use of Refrigerated Air" by H. Kamei and A. R. Tice, North American Aviation, Inc., Autonetics Division; "Expendable Liquid Cooling of Missile Electronic Equipment" by W. W. Hagner, The Johns Hopkins University; "Forced Air Cooling for Power Transistors" by Melvin Marks, Consulting Engineer.

Frank E. Carroll

Ross McFarland Named Director of Harvard Research Center

Ross A. McFarland (M), 1956 recipient of the Institute's John Jeffries Award, has been named Technical Director of a new research center at Harvard University dealing with medical problems created by advances in aviation.

The center will be financed by a grant of $250,000 from The Daniel and Florence Guggenheim Foundation, to be made over a 5-year period. Announcement of the grant and appointment of Dr. McFarland was made by Harry F. Guggenheim, President of the Foundation and 1956 IAS Honorary Fellow, and by Nathan M. Pusey, President of Harvard.

The center will become part of Harvard's School of Public Health in Boston. It will serve three main purposes: to provide advanced training for physicians, biologists, and aeronautical engineers; to unify basic research; and to serve as a clearing house for technical data. The center will study the broad range of human response to extreme speeds, altitudes, temperatures, and toxic agents.

Besides the grant, the Guggenheim Foundation is offering two annual scholarships of $5,000 each for graduate study at the center.

Liberty Aircraft Products Corp. Becomes IAS Corporate Member

Liberty Aircraft Products Corporation, manufacturer of precision components for the industry, has joined the Institute as a Corporate Member.

A subcontractor, the 23-year-old firm makes frames, rudders, flaps, and other parts for major aircraft manufacturers. Erich Schatzki (M) is President of the company.

Headquarters are at Motor Avenue, Farmingdale, L.I., N.Y.

Vitro Corp. of America, Thieblot Division, Joins IAS

Vitro Corporation of America, Thieblot Aircraft Company Division, has joined the Institute as a Corporate Member. The division maintains engineering and administrative offices at Bethesda, Md.

Thieblot specializes in air-frame modification and design and development of aircraft systems. The company was established in 1951 and became a Vitro division in 1956. It also operates the Martinsburg, Va., Municipal Airport under contract to the city.

Recent projects undertaken by the firm are complete production design of the RF-84 Thunderflash and F-105; modification of the F-84F; design, fabrication, and installation of a boundary-layer control system for the Thunderstreak; modification of C-46 power plants; prototype development of engine nacelles for Canadian Britannia; and production engineering on the Seamaster I.

NEWS OF MEMBERS

Members on the move . . . .

This section provides information concerning the latest affiliations of IAS members. All members are urged to notify the News Editor of changes as soon as they occur.

A. J. Carah (AF), former Assistant Chief Design Engineer, Douglas Aircraft Company, Inc., and Secretary of the IAS Los Angeles Section, has been appointed Assistant Missiles Design Engineer.

John H. Carter (M), has been appointed Manager of a new weapon system organization at the Missile Systems Division, Lockheed Aircraft Corporation. He formerly was Associate Director of Research in the division.

Lt. Gen. L. C. Craigie, USAF (Ret.) (AF), has announced his resignation as Vice-President, Engineering, Hydro-Aire, Inc. He will continue as Director of the firm and as a consultant to its management.

Francois N. Frenkiel (AF), member of the principal staff of The Johns Hopkins University Applied Physics Laboratory, has been appointed consultant to the Applied Mathematics Laboratory of the David Taylor Model Basin. He will continue a part-time association with the Applied Physics Laboratory which is sponsoring a new series of monographs on applied mathematics and mechanics under Dr. Frenkiel's editorship.

Marshall B. Gurney (M), has resigned as Director of the Aeronautical Division, General Bronze Corporation, to join Raytheon Manufacturing Company's Santa Barbara Laboratory.

Carl G. Holschuh (M), former Executive Vice-President and General Manager of the Sperry Gyroscope Company Division of Sperry Rand Corporation, has been appointed President and General Manager of the division.

W. A. Klikoff (AF), former Deputy Chief of the Aircraft Engineering Division of the CAA in Washington, D.C., has returned to the position he previously occupied as Chief of the Aircraft Engineering Division in the CAA's Los Angeles regional office.

Armand Lakner (M), has become Senior Project Engineer, Deicer Systems, at Bendix Aviation Corporation's Utica Division. He formerly was Lead Engineer, Electrical and Electronics Section Equipment Group, Business Aircraft Division, for Cessna Aircraft Company.

Harold Lurie (AF), Associate Professor of Applied Mechanics at California Institute of Technology, is on leave of absence for one year at the Oak Ridge National Laboratory. Dr. Lurie has been appointed to the staff of the Aircraft Reactor Engineering Division and is participating in the Oak Ridge School of Reactor Technology.

Joseph F. Manildi (M), formerly Head of Technical Staff Placement, has been appointed Associate Director of the Elec-

Colonel Albert A. Arnhym, an Associate Fellow of the Institute and Director of Information Services of the Air Research and Development Command *(right)*, is congratulated by Lt. General Thomas G. Power, ARDC Commander, who presented Colonel Arnhym with the Legion of Merit in ceremonies at ARDC Headquarters in Baltimore. Colonel Arnhym was awarded for "exceptional meritorious service to the United States by developing a most efficient means of informing all military and civilian elements of this country of the USAF's research, development and test program."

tronic Instrumentation Division at The Ramo-Wooldridge Corporation.

Harold C. Martin (M), Visiting Professor of Engineering, University of Hawaii, has been appointed Acting Dean of the College of Applied Science, second semester, 1956–1957. He is on a leave of absence from the University of Washington.

James L. Murray (AF), formerly Assistant to the Chairman of the Board of Directors, The Garrett Corporation, has joined Republic Aviation Corporation as Administrative Assistant to Republic President, Mundy I. Peale.

Conrad F. Nagel (AF), Vice-President of Aluminum Company of America, has retired after 41 years' service with Alcoa.

Lt. Col. David W. Pearsall (M), has been appointed Executive Officer to USAF Chief Scientist Courtland D. Perkins (F), in Washington, D.C. He formerly was attached to the Armed Forces Special Weapons Project in Washington.

P. J. Ridenour, Jr. (AM), formerly Supervisor of Systems Design for Temco Aircraft Corporation of Dallas, Tex., has joined Thieblot Aircraft Company, Division of Vitro Corporation of America, Washington, D.C., as Design Engineer Checker.

Flight Lt. A. E. Sutherland, RCAF (M), has been transferred from 3rd Fighter Wing in Germany to Air Materiel Command Headquarters, Ottawa, Canada, for duties as F-86 Deputy Project Officer.

Edmund C. Sulzman (M), formerly Vice-President in charge of sales for Jack & Heintz, Inc., has joined Weatherhead Company, Cleveland, as General Sales Manager.

Walter G. Vincenti (F), for 16 years Aeronautical Research Scientist at Ames Aeronautical Laboratory, NACA, has been appointed a full Professor on the Stanford University Engineering Faculty.

CORPORATE MEMBER NEWS

• **Aerojet-General Corporation** has developed a cutting device—Aerocutter—for instantaneous severing of mechanical parts, hydraulic or pneumatic tubing, and electrical cabling. The firm also has announced plans for construction of a new, single-story structure for its Structural Plastics Department.

• **Aerophysics Development Corporation** reports it has solved the problem of dynamic balancing of large rotating elements—e.g., rocket motors, rotating launchers, flywheels, and turbomachines—through design and development of a simple vertical balancing machine. The unit is capable of dynamic balancing of equipment up to 5,000 lbs. in weight, 20,000 lbs. of thrust, 36 in. in diameter, overall lengths of 10 ft., and rotating speeds of 10,000 r.p.m. The firm also has announced completion of an engineering and a research building, part of a five-building plant facility at a 104-acre site in Goleta Valley, Calif.

• **Airborne Accessories Corporation** has opened a branch office at 8402½ Lincoln Blvd., Los Angeles 45, Calif., to serve the West Coast area. Russell Associates, Inc., has been appointed the firm's sales agency in the midwest region east of the Mississippi River.

• **Aircraft Radio Corporation** has published new literature on its communication and navigation equipment, with special emphasis on business flying. Information may be had by writing to the firm at Boonton, N.J.

• **Aluminum Company of America** has announced that zinc-clad aluminum alloy is now available in commercial quantities. The product is available in coil or flat-sheet form, with one or both sides zinc-clad.

• **American Airlines, Inc.,** has installed the first of four DC-6 and DC-7 procedural trainers in Los Angeles.

• **Bell Aircraft Corporation** has purchased the Lake Erie Engineering Corporation. The firm now is a wholly owned subsidiary of Bell.

• **Bendix Aviation Corporation** has announced production of an ultrasensitive radio called Minitrack, designed and built originally by the Navy Bureau of Aeronautics, for tracking the earth satellite.

• **Boeing Airplane Company** has announced delivery of the first jet-tanker transport, KC-135, to the Air Force.

• **Chance Vought Aircraft, Incorporated,** has developed a new change control system which, the firm reports, establishes effective change control—measures and handles problems of introducing changes into production with minimum impact on production schedules. The following objectives were met: change control by engineering from a company point of view, change scheduling by manufacturing through the media of analysts in lieu of change board, complete planning on all changes, measured accumulative impact of changes in production, and improved verification of incorporation of changes.

• **Curtiss-Wright Corporation,** Electronics Division, has developed a "Thermal Memory Relay," a bistable time delay with single-pole, double-throw snap action contacts. The relay is thermally operated with two separate heater circuits.

• **Douglas Aircraft Company, Inc.,** reports the first cross-country flight of the C-133 USAF logistics transport. The firm also has announced that the new version of the Navy's A3D Skywarrior has gone into fleet service and that suspension of the F5D Skylancer will take place after

(*Continued on page 88*)

Improved version of the Albatross with a 16.5-ft. wing span has been developed by Grumman Aircraft Engineering Corporation for USAF Air Rescue Service missions. The amphibian also has larger horizontal and vertical tail surfaces, increased speed and range, and single-engine performance.

The Honorable Edward P. Curtis
Special Assistant to the President for Aviation Facilities Planning

Guest Editorial

The Long View

A condensation of the address by the Special Assistant to the President of the United States for Aviation Facilities Planning at the 1957 Honors Night Dinner of the Institute.

"The story of America's progress in the air from the Wright brothers on is one of amazing achievement which we should never forget in our preoccupation with what is wrong today. Many of us were brought up in Jennies, D.H.'s, and Spads capable of astounding speeds of over a hundred miles an hour with motors which sometimes lasted for 20 hours or more flying time before they let you down in the nearest cornfield. With a Commandaire you could even fly sitting astride the fuselage with no hands on the controls—the forerunner of the automatic pilot. The ultimate in air travel seemed to have been reached in the days when by a combination of two railroads and some trimotor Fords you could cross the continent in the incredible time of 48 hours. Our airspace was relatively uninhabited, and our pilots were certainly uninhibited by regulations and controls. In the space of a few short years, all this has changed. Now we measure top speeds in Mach Numbers instead of miles per hour and passenger-miles flown in the tens of billions. Increasingly large segments of our airspace are becoming crowded, and our traffic control system and airport facilities are growing bottlenecks. For the first time in aviation history our forward progess is being threatened, not by the capabilities of our aircraft or the demands for their use but by our own failure to provide adequate facilities to handle them. . . ."

The paragraphs omitted here cover the historical background of the President's Aviation Facilities Planning Project and the statistical evidence that the bigger and more complex airplanes of the immediate future will fly higher and faster and will compound an already difficult traffic problem.

"In order to take care of aircraft increasing in numbers and complexity, we must proceed at once to modernize our present traffic control system. The present system has real, basic limitations so that everyone agrees that, if we are to have a system sufficiently flexible to take care of our future needs, we must work as rapidly as possible toward a much more sophisticated approach using the best modern technology available. We must, for example, make full use of computers and display techniques to get away from the present slow and cumbersome method of manual flight strip postings. We must at least augment our present overburdened voice communications with some form of rapid simplified data link method to pass essential information back and forth between the controller and the plane in the air and between the controllers themselves. For the past 6 months, our systems engineering team, composed of ten experts in various aspects of the field, has been working on a master plan for such a traffic control system.

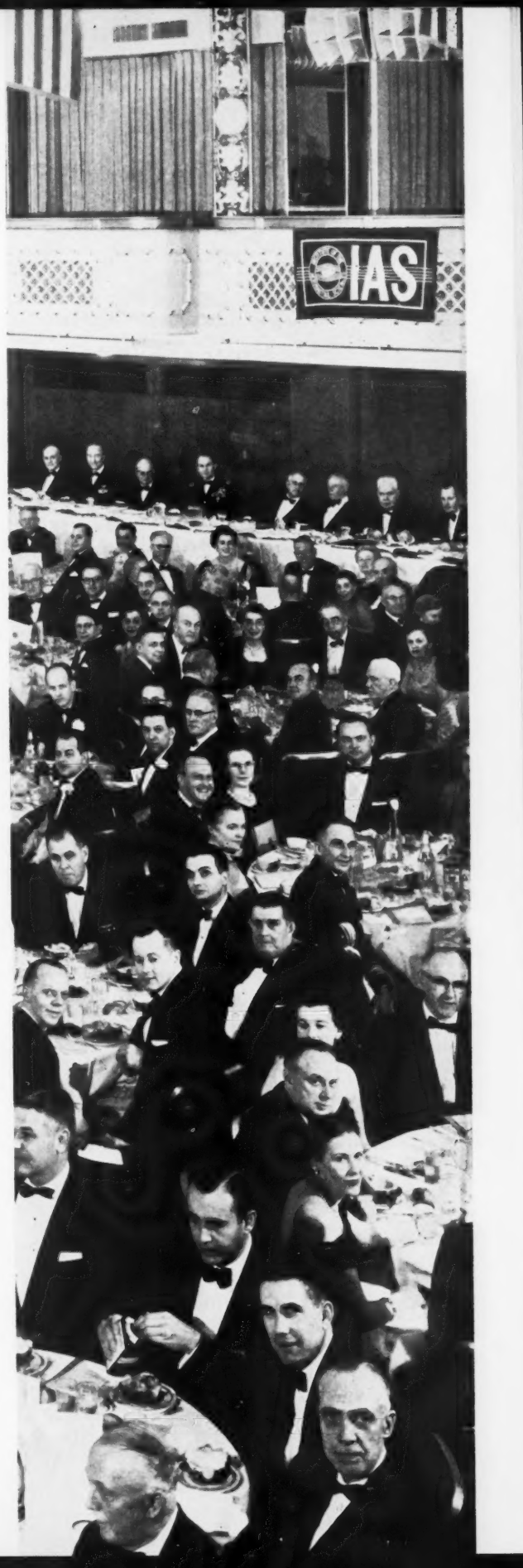
This master plan will become a part of our overall report and recommendations to the President this spring.

"The plan will be organized in stages to permit an orderly transition from what we have today. It will start with recommendations for the general application of techniques which are known, but which either are not yet in use or are used only in a limited manner. The second stage will extend to improved procedures which can be used with existing technology, and finally we expect to outline the areas where further research, development, and testing will be necessary on a continuing basis. The plan, insofar as possible, will attempt to provide for the needs of the various types of user from the minimum-equipped private flyer to the air lines and the military. It will specify the areas in which we believe positive separation will be necessary (such as high altitudes and congested terminals) as distinct from areas and altitudes where a minimum control or none at all will be required. It will permit the military to perform their necessary tactical and training missions with a minimum of interference from normal civil traffic.

As we are able to move increased air-borne traffic more and more expeditiously our airports will tend to become increasingly limiting factors in the system unless they are improved and extended in their capacity both to accept more aircraft on the runways and to improve facilities for maintenance and the handling of passengers and cargo on the ground. In planning to meet these needs, much of the information and much of the work must be done within industry itself. The aircraft manufacturers have a real responsibility in the development of aircraft which are compatible with the ground facilities which can be reasonably provided. There has been a decided tendency in the past to design and build maximum-performance aircraft on the assumption that somehow airports will be built to accommodate them. Instead of demanding more and more concrete, the designers must make maximum use of techniques—e.g., boundary-layer and jet flap control—to improve the take-off and landing characteristics of our future planes. The air lines can do much to standardize many of their procedures and to furnish airport operators with data which only they can provide.

"In addition to this, however, the federal Government has a real responsibility to assist in the planning of an adequate national airport system. As the result of our requirements study, we expect to be able to give certain specific communities a reasonably accurate forecast of the numbers and types of aircraft they must plan to handle during the next 20 years, and the same general pattern will apply to other similar locations as well. These figures, however, must be kept up to date and revised from time to time in more detail than the Civil Aeronautics Administration has been accustomed to do. On the technical operating side, the airport operators must look to the federal Government for development work on optimum airport layouts including such things as parallel runways, high-speed turnoffs, and the relationship of one airport to another in the same area.

(*Continued on page 44*)



The New Emphasis on Systems Engineering

Simon Ramo*

The Ramo-Wooldridge Corporation

An internationally known authority in the field of electronics, guided missiles, and automation discusses an operational philosophy of new importance, describing it clearly as a technical pursuit. Here is one of several especially written articles of interest to the aeronautical engineer which the REVIEW *has scheduled for 1957.*

INTRODUCTION

SYSTEMS ENGINEERING is an old and ever-present phase of every engineering task. The job of integrating the whole, as distinct from the invention and design of its parts, the creation and analysis of the overall answer to a problem, the breaking down of the total into a set of harmonious, specified parts, the assurance of compatibility and consistency in the ensemble, and the relating of that ensemble to the outside world that has originated the need and that will employ the final result—these considerations are present in varying degrees in every single piece or group of equipment, from a chair to a transcontinental railroad. Always some fraction of every engineering team has in effect been devoted to this systems engineering.

Why then have the words *systems, weapons systems,* and *systems engineering* recently been receiving so much attention? Some things written lately about systems engineering suggest that it is a completely new discovery, a fundamental mental discipline, implying perhaps that America's power systems, telephone systems, and railroads might have been created by the random dropping into place from the skies of an assortment of previously unrelated components which just happened to work together fairly well.

The answer lies probably in the fact that today the engineering body is attacking problems of such greater complexity and size, with so many more interactions among the parts and with the external world, and, finally, with a much greater dependence on recently discovered scientific phenomena than was ever true in the past. That part of the whole engineering job known as systems engineering has become much more important. Some of the old techniques used by systems engineers have had to be sharpened and extended; some new ones have had to be invented for the first time to meet the new scale of engineering ambitions. This seems particularly obvious in some military systems involving widespread multicomponent defense systems, guided missiles, and automatic fire control. It is also true, however, in the industrial and commercial world at large where—with the increased speed of production, speed of travel of things and people, larger numbers of interconnections among organizations, need for operating with control over widely extended and rapidly changing situations with a resulting increased communications and data-information problem—the need for the effort to attain new large engineering systems has been accelerated enormously.

COMMON CHARACTERISTICS

The existence of systems engineering is now widely noted, but very little has been set down to describe systems engineering as a technical pursuit. This is understandable also because systems engineering is so broad that—as with philosophy, religion, education, and government—it is not easy to set down a group of simple principles that determine how to practice it well. Nevertheless, certain common characteristics of a typical systems engineering task can be listed. Furthermore, certain tools used often by good systems engineers can be described with the obvious thought that one who has acquired familiarity with these tools and, furthermore, has the basic talent for integrating the whole of a complex situation will be more successful

* Executive Vice-President.

in practicing systems engineering than an equally competent individual who is unfamiliar with these tools. These listings, unfortunately, are a far cry from a treatise on the subject of systems engineering. They are related, however, to such a goal. At least one way to arrive eventually at a clear understanding of the elements of systems engineering as a special technical discipline is to list the common characteristics of systems engineering and the tools that are employed, do enough case studies of good systems engineering accomplishments, and, finally, see from all of this the general principles that dominate the art. In this article we can do little more than some of the initial listing.

In noting some characteristics and tools in the following paragraphs, it will be assumed that our attention is restricted to the more complex engineering tasks. Here, typically, we find a large number of specialized fields of engineering and science required in each project. The systems engineering task usually involves integration of several of such fields as, say, aerodynamics, electronics, chemistry, metallurgy, astronomy, and hydraulics. With the job large and difficult, usually representing a substantial advance of the art, a systems engineering team must include experts in the scientific fundamentals of the various specialized fields that enter into the problem.

The Physicist and the Practical Engineer

The growing dependence on the exploitation of recent scientific discoveries usually suggests that an important ingredient in the systems engineering team is that type of scientist who fully understands the recent scientific discoveries. Ideally, he is sometimes the individual who has participated in making the discovery. But there is another reason why this class of more fundamental scientist is important in a good systems engineering staff. If the collection of equipment that makes up the system is sufficiently new and if there are enough parts thereof, then the analysis of its operation can involve difficult conceptual problems in physics and mathematics. The analytical work, in which one attempts to set down at least approximate laws of behavior of the system in order to predict its operation, requires a kind of capability on the part of the systems engineering organization entirely the same as that employed by a skilled scientist in understanding any other segment of nature. If the problem is large enough and complex enough, it does not help very much to have the assurance that everything that can happen with the system can be traced to some few fundamental laws of physics. It still requires an outstanding physicist to advance from those fundamental laws to the specific prediction of the behavior of the conglomeration.

Theory and analysis become of increasingly greater importance as a system becomes large, complex, and expensive. It is then no longer practical to rely entirely on trial and error which works so well in simpler and less new engineering problems. Even with the most solid analytical work as a preparation, enough always must be left to large-scale experimentation to finalize the understanding and the successful workings of a system with the result that the experimental work is difficult and costly. Accordingly, even with the best use of theory and analysis, the team still requires yet more of the fundamental scientist—namely, one skilled in the design of scientific experiments and controlled tests intended to pin down crucial aspects that must be understood better to confirm an understanding and to prepare for the next step.

But no matter how new and how complex a system is and accordingly how dependent it may be on the best scientific minds and training for its success, it is no less dependent upon the skills and judgments of the practical engineer. The system always contains a large fraction of components that are similar to those that have been designed before. The practical steps of assuring progress without rediscovering and redesigning all the practical technical art continue to be indispensable in systems engineering. Equally important with his stature in the design of the system is the practical engineer's contribution to the experimental modifications and adjustments and in the data gathering and trouble shooting necessary to make the system work. Finally, these experienced engineers must put it into production and operation as a reliable complex.

We have, then, the need for a variety of specialists and a spectrum of types of technical learning and approaches from that of the practical engineering designer to the abstract scientist. What about some of the special tools used by this team in successfully prosecuting systems engineering?

Analytical Tools

Let us list some of the analytical tools first. In describing the operation of the system, in stating the requirements for its performance, and in specifying the component parts, probability theory is more important in systems engineering than in the average engineering problem. Never is it possible to describe the conditions which a small individual piece or a large complex of equipment will meet with absolute accuracy. The inputs to the system must always, if we insist on being precise, be stated in terms of some sort of a spectrum of possibilities with a probability distribution that tells us the relative probabilities of different possibilities. Also, the response to these input conditions cannot be precisely stated not only because the input is not known with precision but because of two other factors as well, internal to the system. One is that, if the system is very complex and consists of many parts, we are forced to do some averaging of the effects. It becomes impractical to be precise in accumulating all of the effects that contribute to the system's final performance in a quantitative sense. The situation is like that to which we are accustomed when describing the actions of a group of people rather than a simple physical machine. This is made more obvious if one considers that a typical large systems engineering

problem concerns a combination of men and machines, and it is the totality of the operation of the system which we cannot describe with utmost precision.

In addition to this, it is also true that we do not know with precision the characteristics of the components of the system, having to describe these also with a certain margin of error—be it the indefiniteness from a human component or from noise in a vacuum tube, lack of precision in manufacture of an electromechanical component, backlash in a gear-train, or any other source of random error within the system. Accordingly, one does not speak of designing a defense system that can shoot down all or half or any other set fraction of enemy airplanes having a specific performance and arriving in a specific manner; rather, one speaks of having a satisfactory given probability figure for the main objectives and a sufficiently low probability figure for maloperation of the system. What the average engineer learns in school about probability theory is far from sufficient for systems engineering. The average theoretical physicist usually is at home in physical statistics, but he still must set up the detailed formulations of probability theory that apply well to systems engineering problems. There are fewer main elements in the most complex systems we have to consider than there are molecules in the average volume of gas around which physical theories have been built. However, the system's parts are enough in number, sufficiently different from each other, and difficult enough to describe with precision that determining the accuracy of the whole collection can call for the best minds using the best tools of mathematical physics.

System Stability

A second common problem in the analytical or theoretical field is that of system stability or, more broadly, the "unwanted mode" problem. The system may, on paper, succeed in meeting its objectives for its normal operation, but any practical physical system has the possibility of many modes beyond those considered desirable. Of course, the larger the system, the greater the possibility of large numbers of feedback loops and interactions. The common concept of instability is one example. Here we are usually satisfied if a transient, once started, dies out quickly enough so as not to interfere with the main operations of the system. But this is too limited a statement of the "other mode" problem. In a telephone system, for example, one must include in its design the possibility that an operator may dial the wrong number, may hang up before the call is completed, or may leave the phone off the hook. These are not elements of instability; they are examples of other modes for which the system was not basically intended. The situation is further complicated by the fact that the simple notion of a steady-state condition and a transient at the beginning or end of operation is an oversimplification; many large-scale and difficult systems engineering problems, such as the operation of a typical air-to-air or surface-to-air guided missile, may be best looked upon as a transient from beginning to end so that instabilities in the usual sense cannot be isolated and dealt with in a simple fashion.

Most of available stability and servo theory is based on the assumption of few modes and linearity. Systems engineering in the large involves many modes, random effects, and nonlinearity all superimposed. The problem of a lack of precision in the description and quantitative analysis of a complex engineering system and the instability and other modes aspects are especially complicated by the degree to which nonlinearity appears. Nonlinearity makes analysis difficult, but it offers a much wider choice of possible system configurations and performance. It is not alone the presence of human operators in a large engineering system that makes for nonlinearity; it is also the fact that frequently—as, for example, in guided missile systems—we cannot afford to operate alone in the linear parts of the characteristics of the various components. We must, for example, rely on use of early radar data, even when the signal-to-noise ratio is poor. We must discriminate between noise and targets, even if in the process we make occasional bad errors, if only our average performance is improved. (A miss is often as good as a mile.) We must use all of the control surface potential in a missile, even though the controls are saturated part of the time, because it is even worse to accept the weight and power increase in designing oversize devices that will permit the luxury of operating in the linear region. An overall systems performance description for a typical military system is not linear. For instance, the size of miss of a guided missile shooting down airplanes hardly affects the kill potential until the miss distance passes the important dimensions of the plane; after that, the relation of kill to dispersion changes to a new relation. In typical industrial automated systems, we may want one operation by the system if a particular situation occurs and quite a different one if the input passes a certain point. In quality control, for example, the automatic system may do nothing until the input signal based on measured tolerance reaches a certain value, after which the plant may be shut down. These are oversimplified examples, but it can be seen that, in general, nonlinearity offers optimization possibilities that cannot be overlooked.

The Importance of Simulation

With analysis and theory difficult and with large-scale hit or miss experimentation expensive and time-consuming on large and complex systems, it is clear why large-scale computers and simulators are important in systems engineering. They aid in the analysis, predict performance, and test designs. What is not so obvious is the extent of skill required in the design and utilization of such machines to offer the maximum assistance in systems engineering. Even the use of a large-

scale digital computer merely for the purpose of making computations which would otherwise be completely impractical usually involves just as much skill in the programing and computation art as in any other technical field associated with systems engineering. In the simulation operation, a great deal of ingenuity and scientific effort are needed, and it pays off heavily. Absolute and complete simulation of a large-scale system would appear to be impossible by definition. Unless there is some substantial difference, it cannot be called simulation—it is the real thing; on the other hand, if the difference is substantial, there always must remain a doubt as to whether the system's behavior has been properly predicted and tested. The ability to pick out the core of the problem, the depicting in a simulated system of that which must be studied, and the art of separating the parts of the problem that can be understood in isolation leaving to the final total systems test only that which depends on full-scale interaction—these techniques are the stock in trade of a good systems engineering team, and they are generally arrived at by years of direct experience.

So great are the difficulties of carrying off full-scale tests of large and complex systems that often the system must be designed around the possibilities of effective testing, just as attention must be given, in comparing candidate systems, to the fact that the performance of one system might be easier to predict than that of another.

Systems Engineering Direction

The management of systems engineering deserves special comment. Systems engineering is more likely to be closely associated with top management of an enterprise than the engineering of the components of the system. If an engineering task is large and complex enough, the arrangement-making problem is especially difficult. Commonly, in a large job, the first and foremost problem for the systems engineers is to relate the objectives to the technical art. It is not only a question of economics, it involves understanding the military or industrial objective and the relationship between what is expected of the system and the existing organizations and apparatus with which it must work. Finally, the schedule, cost, and technical performance, as well as the required compatibility with existing other physical resources, result in a set of compromises. In fact, these compromises continue to be adjusted during the entire systems engineering task.

This closer association between systems engineering, arrangement-making, and top management has often created confusion as to what systems engineering is and how it should be directed. For example, one top executive of an industrial concern recently expressed his belief that systems engineering is "when you have the prime contract," which, of course, confuses the systems engineering problem with the control of the funds of a large project. Another example is the tendency to put at the top of a systems engineering effort a nontechnical man with the idea that the difficult arrangement-making problem and the relationship with the top management of a project require in the top engineering position someone who is "broad" and who mixes well with people. There is no question about the need for the top systems engineer to be broad and to mix well with people. But systems engineering is a highly technical pursuit and, if a nontechnical man attempts to direct the systems engineering as such, it must end up in a wastage of technical talent below. This is especially important to point out because often the top systems engineering direction job is given to a nontechnical man with the additional argument that it saves technical people for basically technical jobs. It is well to recognize that systems engineering direction must have a close link to the top management of any substantial program which includes a large amount of system engineering, but this should not lead to an arrangement in which the difficult systems engineering does not get organized and operated as a basically technical job.

In looking further into the qualifications for systems engineering direction, it is well to dwell on one important aspect not yet sufficiently emphasized. Because it is difficult to be precise in the description, evaluation, and analysis of a large engineering system complex and because quantitative reasoning is difficult by the very nature and complexity of the technical systems engineering problem, it is easy for loose and completely qualitative thinking to prevail. A poor systems engineering operation can result, in which the chief decisions are made on the basis of pure hunch, and no logical reasoning or attempts at quantitative evaluations are made. Candidate approaches are not compared objectively. An approach is arbitrarily chosen that thus dominates the whole program because seemingly one person's guess is as good as another's. The greatest need in systems engineering today is to increase objective, quantitative thinking and to accept and match the challenge of the technical difficulty of large-scale systems development with high technical systems engineering skill.

The top systems engineer must be a good manager, of course. He must also be a good scientist and engineer, with considerable breadth. The top engineer of each specialty or component field that makes up the system must also be basically a good systems engineer even though his major detailed knowledge may be in the field of his specialty. Below him can be the specialist-experts in the difficult fields that are necessary for the whole operation. The relationship among these experts cannot be smooth and cannot be handled in proper balance for the good of the system as a whole unless there is at least one expert in each of the component areas who is basically a systems man.

The Need for University Training

A final word about the teaching and training of systems engineers. Ideally universities should supply

a flow of systems engineers just as we hope they can continue in future years to supply enough electrical, aeronautical, and mechanical engineers and physicists and chemists. However, it is probably considerably more difficult to arrange a specialized course in systems engineering than in the other pursuits. It would require graduate work and this graduate work should be given only to those who have the special basic potentialities for systems work. Some individuals, brilliant as they may be, tend to be so only if they confine their work to a highly specialized area. Others seem to have a special knack for the problem of relating one field to another. Some cannot work easily and make progress in a field unless they are able to think about it with great depth and detail. The complexity of the average system engineering complex requires the type of individual who can feel at home in analysis or experimentation even though it is impractical for him to understand in detail all of the parts.

If there were good ways of discovering these individuals early, it would save a great deal of time. Then it would be possible in college to add to their bag of tricks the specific tools that are most often used by systems engineers, and it would be possible in industry to place them early as apprentices to experienced systems engineers. For some time, however, probably the burden of training systems engineers will go to the organizations carrying on the work, looking to the universities only to give them a well-grounded graduate in the physical sciences and engineering.

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Guest Editorial (*Continued from page 39*)

They should also know from some central authoritative source what maximum runway acceptance rate they should aim to provide.

"In considering how the federal Government can most effectively and efficiently discharge its responsibilities in the field of aviation, the foremost problem is one of organization. There is probably no activity of the Government which directly involves so many different departments and particularly is so concerned with the daily operating activities of the civil and military. Civil and military aircraft use the same airspace and, to a very considerable extent, the same traffic control and communication system. They have, however, different missions to perform and do not always expect or require the same type of service. This leads to genuine, legitimate differences in their approach to the development and operation of a common system. The long-standing dispute about GCA versus ILS and the TACAN-VOR/DME controversy are two outstanding examples, but there are many others which were somewhat less expensive to the taxpayers. The only mechanism we have today is a complicated maze of committees that endeavor to resolve conflicts as they arise. In many instances this works well, and a large number of operating problems like joint use of airports and allocations of airspace are resolved with reasonable satisfaction to all concerned. Major problems of the kind I have mentioned, however, by the nature of the coordinating system, tend to drag out to the point where finally the only possible solution is an unsatisfactory compromise.

"This problem is particularly critical in the field of research and development for a common system of air traffic control where the Services tend to work on systems designed to take care of their own peculiar requirements—and which may or may not be compatible with what the Civil Aeronautics Administration is developing. Some progress in coordination is being made in this direction, but we must somehow devise a simpler, more authoritative form of organization to control both research and operations if we are to avoid in the future the time-consuming and expensive controversies we have had in the past.

"There seems to be a tendency in some quarters of the aviation world to feel that my group will come up with some magic formula which will solve our problems overnight. You know as well as I that "there ain't no such animal." This certainly does not mean that our problems are insoluble. Quite the contrary—there is an equivalent to the magic formula, and that is a systems development organization backed by the best talent in government and industry and set up to work continuously on these ever-changing problems. Airplanes and power units have made their amazing progress by just such continuous long-range research and development. A comparable effort on our ground facilities should keep this phase in balance with our constant progress in the air. The job *can* be done. . . ."

▲ ▲ ▲

An estimate of future air traffic growth, with discussion of specific economic factors which justify such a forecast.

Some Economic Factors in Air Transportation

Theodore P. Wright*
Cornell University

Publication of this study has been made possible through special arrangements with the author. It consists principally of Chapter 5 of a paper entitled "Air Transportation," prepared after a special committee† of the 6-year-old Israel Society of the Aeronautical Sciences selected Dr. Wright as its First Biennial Lecturer. Unfortunately, unrest in the Near East prevented delivery of the paper as scheduled in Tel Aviv during December.

While it would be impractical to attempt to publish the full, 70-page, profusely illustrated manuscript, the REVIEW *is indebted to Dr. Wright for assistance in presenting this comprehensive and enlightening portion of his views*—ED.

A MOST IMPORTANT and noteworthy characteristic of air transportation since its start around 1930 has been its remarkable and steady growth. Many forecasts have been made concerning its future growth prospects, and, almost without exception, these have erred on the pessimistic side. Usually, in forecasting the future amount of traffic, a straight-line extrapolation from the past record has been plotted. Account has not been taken properly of the compounding nature of past growth—that is, the upward concavity of the curve when plotted on rectangular coordinate paper. Thus, the past has shown geometric progression whereas the forecast is arithmetic. A geometric progression plots as a straight line on semilogarithmic paper, and I have, therefore, used such a medium in my own assessment of the future.

In Fig. 1, the past achievement and certain forecasts are shown. Good agreement with this straight-line plot appears for the period 1930–1950. For such period, an annual increase compounded is at the following rates achieving traffic in billions of passenger-miles shown:

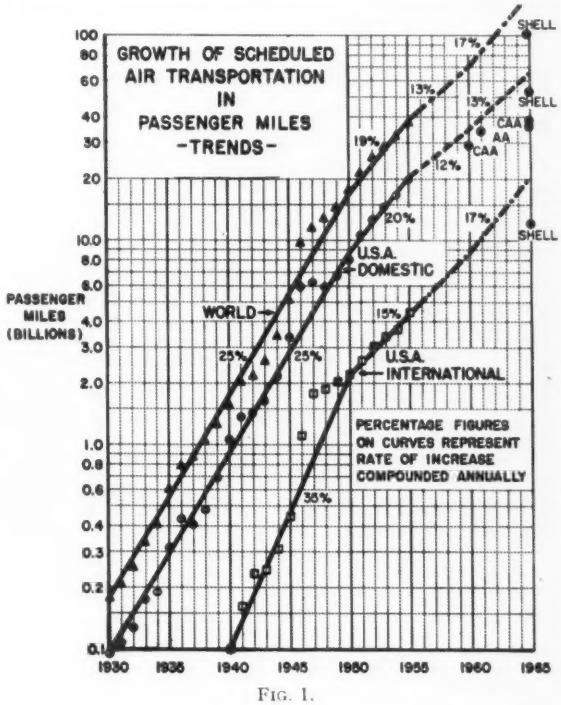

FIG. 1.

U.S. domestic	25 per cent	to 8.0 billion
U.S. international (from 1940)	35 per cent	to 2.2 billion
World	25 per cent	to 16.5 billion

For the succeeding period, 1950–1955, the points lie closely along a rate curve:

U.S. domestic	20 per cent	to 20.0 billion
U.S. international	15 per cent	to 4.4 billion
World	19 per cent	to 38.0 billion

Now, what of the future? In submitting my estimate, I am constrained to quote from the excellent article appearing in the June issue of *Shell Aviation News* entitled "Behold the Turtle—the Difficult Art of Predicting the Growth of Air Transportation":

"The history of aviation growth forecasting is outstanding for the coverage of the forecasters who, boldly or conservatively, come forward with new predictions

* Vice-President—Research, and President, Cornell Aeronautical Laboratory.

† Theodore von Kármán, Chairman, AGARD; William Sears, Director, Graduate School of Aeronautical Engineering, Cornell University; Hugh L. Dryden, Director, NACA; Sir Ben Lockspeiser, Secretary, British Department of Scientific and Industrial Research; Joseph Peres, Dean of Faculty, University of Paris; and H. J. van der Maas, Professor of Aeronautics, Technological University of Delft, and President, Netherlands Aircraft Development Board.

as soon as experience has laid low the earlier ones. Existing amid such heroic heralding, the industry has, perhaps of necessity, developed a degree of resistance to the excitement that these prognostications would seem to suggest."

Nevertheless, the inaccuracies of these forecasts on the low side have been to blame, at least partially, for the existence of several extremely serious problems such as inadequate provision of air traffic control facilities to handle present United States traffic and, in many instances, unsatisfactory airport facilities. And so we must continue to make forecasts, using the best available statistics and the best possible assessment of relevant factors.

With these things in mind, I forecast the growth of traffic in billions of passenger-miles for the next 5-year period, 1955–1960, as shown:

U.S. domestic	12 per cent	to 35.0 billion
U.S. international	15 per cent	to 8.7 billion
World	13 per cent	to 70.0 billion

On the favorable side for this continuing growth are the assumed continuation of population growth at $1^1/_2$ per cent per annum and of gross national product of about 6 per cent in the United States (both geometric progression factors) and the continuing improvement in equipment, technique of operations, and facilities. The growth factor rate is reduced from that of the preceding 5-year period because of approach to saturation on long-haul traffic, the unavailability of optimum equipment to exploit the short-haul traffic more rapidly than at present, and the inadequacy of the airways system and resulting accident potential mentioned above. I am fortified in these forecasts by the close approximation to realized gains during 1956. The rate for United States international air transportation does not have some of the above adverse factors affecting it, which prompts me to continue it at the same rate as was realized in the preceding 5 years. World air transport is shown at a rate between the two.

I believe forecasts covering periods further ahead than 5 years are susceptible to so many uncertainties that they must be viewed as speculation rather than probability. However, I have tried to analyze certain events in the 1960–1965 period and predict traffic on the conclusions reached. By 1960, we will have gained in long-haul traffic through encroachment on other means of transportation to the maximum extent probable, which means that the increase must be predicated on the basis of the potential for generation of new traffic sources. I venture the following in which rates of growth (in billions of passenger-miles) are steeper than the 1955–1960 period quite largely because of the favorable effects of the new jet and turboprop fleets which will then be well established in operations, with increased speeds, efficiency, and carrying capacities:

U.S. domestic	13 per cent	to 64.5 billion
U.S. international	17 per cent	to 20.0 billion
World	17 per cent	to 155.0 billion

Here again, continued growth of population and gross national product together with maintenance or increase of general standards of living are assumed along with the obviously needed hedge of no major world war.

In Fig. 1 are shown the forecasts of some other investigations which indicate by comparison the optimism (perhaps overoptimism) of my estimate. I have indeed reckoned on real mass air transportation during that period.

Now, having presented these forecasts, I will discuss in considerably more detail the economic factors bearing on traffic growth which, it seems to me, justify them.

The factor of growth of population seems to require no special comment and should affect the potential market directly. Growth of the gross national product, however, at its past rate is less certain. This depends on the continued advancement of all science and technology. The prospect of a new power source —atomic energy—coupled with the compounding effect of scientific advance leads me to be optimistic that gross national product increase in the United States and, indeed, in the world, will continue at about a 6 per cent annual rate. We accomplish in 5 years now what took 25 a generation ago. One recalls a quotation from Thomas B. Macauley made in 1830, "Why is it that when we can see nothing but progress behind us, we are led to expect deterioration ahead?"

There will continue for 5 or more years (to 1960) to be an *encroachment of travel by air* from other means of transportation. Some factors are:

(1) Increasing disparity in speed of travel by air over other means (from three to ten times as fast depending directly on distance and terrain) will be determining for many persons in the means selected. People are in a hurry, and speed increase of means of travel other than air is at a standstill. The 1960–1965 speed jump when jet aircraft predominate on the airways will be particularly large—from 360 to 550 m.p.h.

(2) Convenience and comfort of air travel will be improved with the advent of the jets. Passengers already comment favorably concerning smoothness of jets. Indirectly, these gains are effected by the shorter time in travel on a given length trip. There may be an added increment in comfort by 1965 if gust alleviation is developed.

(3) Reliability and regularity will be improved by the availability of more all-weather flying facilities and improved air traffic control.

(4) A marked increase in short-haul traffic will take place through the introduction of more suitable equipment, possibly including planes with vertical take-off and landing capabilities. Here, however, efficiency improvements are needed to permit profitable operation at lower fares. The potential of this short-haul market in the United States is given in Table 1. This shows the approach to saturation at over 1,500 miles distance and the great potential for air travel encroachment for distances of less than 250 miles. (Commuter traffic is excluded.)

TABLE 1

Distance (miles)	Per Cent of Air Travel to Total on Common Carriers	
0–100	1.2	
101–250	10.0	2.25 (under 250 miles)
251–500	23.0	
501–1,000	52.0	
1,001–1,500	63.0	74.3 (over 1,000 miles)
Above 1,500	78.0	

(5) The trend is for the railroads to go out of the long-haul, first-class passenger field entirely as shown by the recent request to Government for fare increases of as high as 45 per cent.

Next I will discuss factors favoring the *generation of new traffic* as distinguished from encroachment on the traffic now enjoyed by other types of carrier.

(1) *Fare Reduction*—There has been a great reduction in air fares in the past due to increased efficiency of equipment and operation. Fig. 2 shows reduction in fares since 1926 in cents per passenger-mile both on the basis of current charges and such figures adjusted to the cost of living index. One observes that, since 1935, fares charged have remained fairly constant at about 5.5 cents/passenger-mile. On the adjusted basis, they have dropped to about half that figure which is a measure of improved, overall efficiency of operation since costs have risen proportionately with increase in cost of living index. Since 1948, fares have differed between first class and coach to 1955 figures of 6.02 cents first class, 4.35 cents coach, and 5.34 cents weighted average as shown. Adjusted to the cost of living index (1935–1939 base) these are 3.1 cents, 2.3 cents, and 2.8 cents, respectively.

Shown also are air fares, unadjusted and adjusted to the cost of living index, for United States international travel. These are $6^3/_4$ cents/passenger-mile and $3^1/_2$ cents, respectively, in 1955. Lower rates when traveling as tourists or at off-season times are available.

The improvement of the airplane itself as a transport vehicle has been a most important factor, attaining increased speed due to reduction of drag coefficient and increased size, among other factors. Rather than show this improvement in efficiency in terms of operating cost per passenger-mile (a difficult figure to get on a comparable basis) for the many present types of aircraft, I am indicating the improvement on Fig. 3 in terms of break-even load factors. Here is shown the change in this factor and, as well, the actual average load factors achieved in United States domestic air transportation from 1930–1955. The difference between the two curves represents profit or loss depending on whether the actual is above or below the break-even figure. There is an indication of the time at which new equipment was introduced, although it must be realized that load factors are averaged for the mixed fleet as then constituted, consisting possibly of one half new and one half older types of plane during a period 2 to 5 years after the introduction of new models. Approximate fares for each period are also shown. In determining break-even load factors, these fares and 100 per cent overhead are assumed. Also, it is assumed that individual aircraft of the fleet are in general flown at ranges which are optimum from the operating cost standpoint.

A few comments on the matter of load factor are desirable. An air line flies seats from place to place. Its sales efforts are directed to filling as many as possible of these with paying passengers. It costs about as much to fly an empty seat as an occupied one. Profit achievement, therefore, is very sensitive to load factor—the ratio of filled seats to the total available. Break-even load factor is the percentage of available seats that must be exceeded in order to achieve a profitable operation.

It should be noted that what might be conceived as being a desirable objective, a 100 per cent load factor, can never be achieved for the whole operation (though it may be on individual flights) as then, on a considerable number of occasions, many passengers desiring to fly would not be able to book space. For good overall

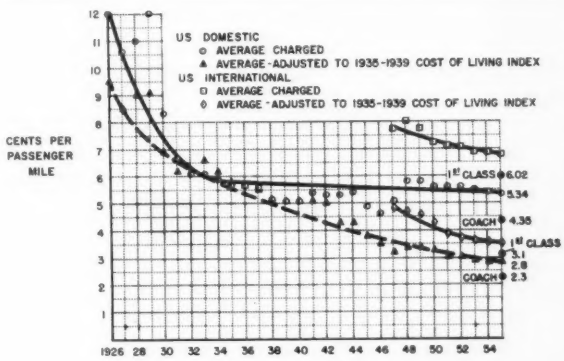

FIG. 2. Air fares.

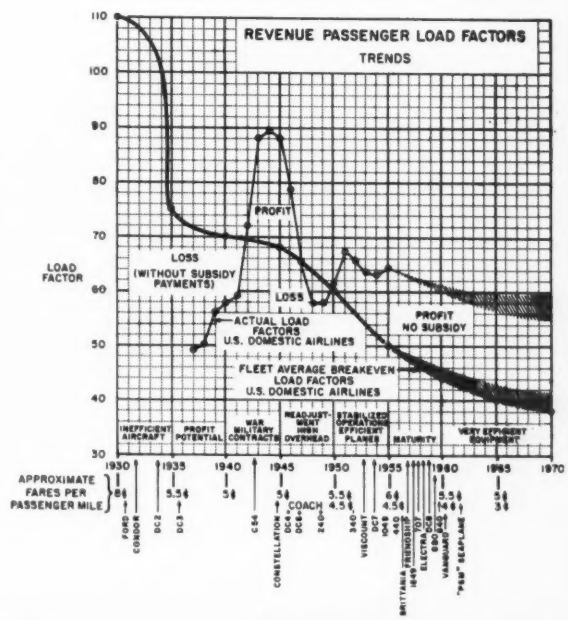

FIG. 3.

scheduling, a 70 per cent load factor appears optimum. The 1955 figure in the United States was 63 per cent.

Shown also in Fig. 3 are special economic or other conditions affecting load factor for each 5-year period. The continuing decrease in break-even load factor after jets form an important part of the fleet in 1960 is important because of the possibility that this holds for further fare reductions. Then, too, operating efficiency may be expected to improve further as this relatively young industry gains in maturity and experience and more effective operations in general.

Now, I present a discussion of the importance of fares in the growth of air traffic and the achievement of mass air transportation.

In determining whether one will fly, there are several economic factors to be considered. The first of these is *a desire to travel*. The reasons for travel and the proportion each has at present are business, 36 per cent; personal, 60 per cent (which may be for visits, vacations, or emergency); and all others, 4 per cent. Next, our potential passenger must have, in fulfillment of his desire to travel, *a will to spend* his money for transport by airplane. This may be because of the speed of such means or pleasurable anticipation of the experience, and this must not be accompanied by any deterrent from fear. Finally, before this potential air traveler actually books his ticket, he must have the *ability to pay*. It is obvious that, as fares go down, a larger and larger percentage of the population achieve the ability-to-pay status. Of the 15,000,000 or so people in the United States who have ever flown, some 5,000,000 are on business expense-account travel and can therefore conservatively be discounted in an investigation of potential market expansion due to fare reduction. Some 10,000,000 is then the base from which we start.

In Fig. 4 are given curves to illustrate and defend a proposition I now state—potential market for air passengers varies inversely as the cube of the fare. Such a graph plots as a straight line with negative slope on logarithmic paper (center curve). This rule will only hold between limits defined at one end by availability of a reasonably safe, rapid, reliable, and efficiently operated service and at the other by the point of diminishing returns where saturation of possible market starts to occur. From there it tapers off to a point of zero fare and total population. In United States domestic and international and in world air transportation, we are now within these limits of application of the inverse cube rule.

The United States domestic, presently available market, as indicated above, is at 10,000,000 persons, utilizing air travel at an average fare of 5.34 cents/passenger-mile. The rule states that, if fares were to be dropped to 3.31 cents/passenger-mile (present first-class rail fares), then this potential air travel market would expand to 42,000,000 persons—a fourfold increase. There will, of course, be a time lag between lower fare announcement and attainment of this market in terms of trips sold. The occasion to fly must arise and also the advantages and lower costs must be widely disseminated and appreciated. The amount of such lag is most difficult to foresee, but the potentially larger market will be present.

The point of diminishing returns mentioned above will occur at about 50,000,000 (approximately 30 per cent of the population of the United States) as shown in Fig. 4, so that decreases in fare to 2 cents/passenger-mile (present bus rates) might mean a potential market of 100,000,000 rather than the entire population as the straight-line extension indicates.

I have shown on the same graph a curve (upper curve) defined by an abscissa in terms of the percentage of families receiving more than the amounts indicated in

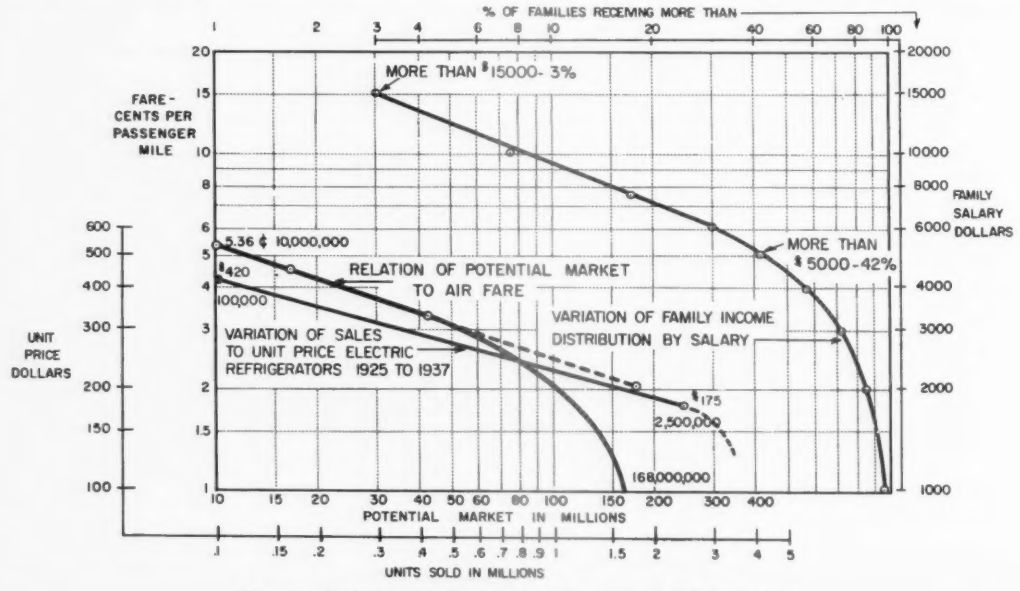

FIG. 4. Variations approximating the inverse cube relation.

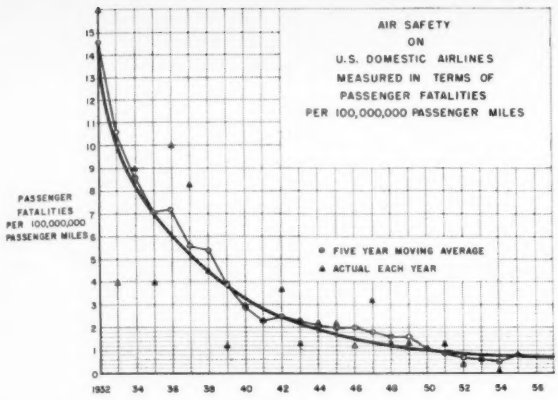
AIR SAFETY
ON
U.S. DOMESTIC AIRLINES
MEASURED IN TERMS OF
PASSENGER FATALITIES
PER 100,000,000 PASSENGER MILES
PASSENGER FATALITIES PER 100,000,000 PASSENGER MILES
• FIVE YEAR MOVING AVERAGE
▲ ACTUAL EACH YEAR
1932 34 36 38 40 42 44 46 48 50 52 54 56

FIG. 5.

the ordinate as family salaries. Through its straight-line portion these range from 3 per cent receiving more than $15,000/year to 30 per cent getting more than $6,000/year. It then falls off from the straight-line relation to 42 per cent receiving over $5,000, 70 per cent over $3,000, and finally to 95 per cent getting more than $1,000. This curve indicates a measure of the ability to pay and roughly parallels the curve of air fare versus market potential described above.

Another indirect statistic relating to the phenomena of market elasticity is the plot of electric refrigerator prices versus sales in the United States from 1925 to 1937 (lower curve). It followed this same trend. For manufactured products, the reduction in price is possible because of reduction in manufacturing costs which also follow an inverse cube relation (a relationship which I developed in the 1920's for aircraft construction, the so-called 80 per cent learners' curve, and which was proved correct in the large-scale production experience of World War II).

These data appear to warrant the conclusion that fare reduction made possible through improved aircraft and operating efficiency will result in a tremendous broadening of market potential for air transportation. One is fortified in one's optimism by the record of traffic increase in the United States when air coach service made available fare reductions from first-class rates. Since 1948 when coach service commenced, the proportion of such use to total passenger-miles of air travel has increased to 35 per cent. This was during a period when air traffic growth was expanding 20 per cent annually compounded and indeed contributed importantly to that increase. Fares charged for air coach travel have been about 72 per cent of first class. The decrease in service rendered or accommodations provided has not been great, consisting of the addition of seats as represented by five across the fuselage instead of four, elimination of free meals aloft, and possibly one or two other changes of little importance to the air traveler.

Coach service at reduced rates already has achieved a rather rapid increase in use by the traveling public, indicating that the lag in public appreciation and acceptance once lower fares are announced may not be very great.

(2) *Safety* is a factor that must be continuously stressed. Without ever-improving safety, many persons through fear simply will not take that first trip. Although statistics are difficult to sell to a timid, would-be air passenger, they are, nevertheless, convincing. In Fig. 5, the record in United States domestic air transportation from the start in 1932 through 1955 is shown in terms of passenger fatalities/100,000,000 passenger-miles. The record for each year is spotted, and then points are shown for a 5-year moving average. This method averages out individual years where special occurrences have made for high or low results and permits a proper trend curve to be plotted. Consistent improvement from 10.6 passenger fatalities/100,000,000 passenger-miles in 1933 to 0.6 in 1953 appear with the trend curve pointing toward a continuing improvement. I am inclined to believe that continuation at a figure below 0.8 will make fear an ever-decreasing obstacle in the path toward mass air transportation.

(3) *Speed*—reduction in travel time—is the *raison d'être* of air transportation. It is what we have to sell. The continuing achievement of reduction of travel time will result in generation of new traffic over and above the air travel acquired by this factor applied to the encroachment on the market of other existing means of transportation. Let us look at historical precedents. The advent of steamboats vastly increased over-ocean travel from that existing in sailing vessels which were eventually completely supplanted. Similarly, the railroad created markets of which it was impossible even to conceive when considering covered-wagon traffic across the United States. Again, the automobile made a new market of a completely different order of magnitude from that which it supplanted in horse-drawn vehicles. Many estimates of air travel potential have failed to appreciate this and have, therefore, placed unjustifiably low limits by considering only the encroachment on the market of other means of transportation.

In Fig. 6, speed increase through the years is shown. A smooth curve is plotted which approximates a 5 per cent annually compounded rate. The points

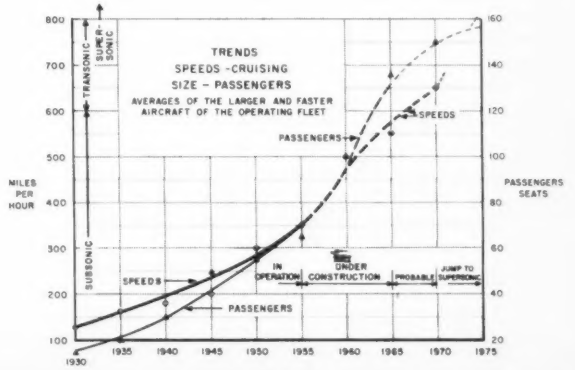

FIG. 6.

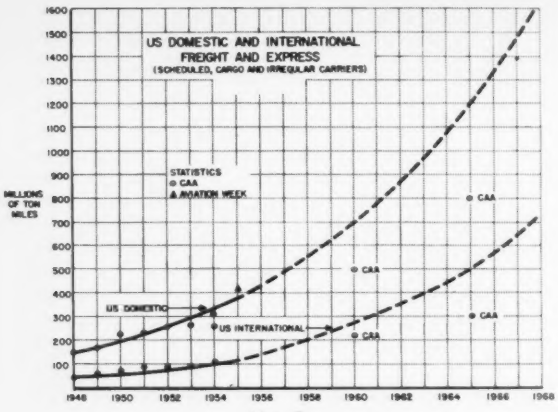

FIG. 7.

shown represent the speeds of the newer equipment in service when their numbers have made them an important part of the fleet. From the Ford Trimotors of 1930 at 115 m.p.h., the air transport fleet has acquired planes in important numbers that bring present speeds to 350 m.p.h., which, with the jets now on order, will place the point at 450 m.p.h. in 1960 and 550 m.p.h. in 1965. These will hold or possibly increase at a less rapid rate thereafter to perhaps 650 m.p.h. by 1970. At some more distant year, perhaps 1975, there will be some supersonic passenger-carrying air transports in use with 1,500 m.p.h. (Mach 2) probably developed for a few specialized services.

Fig. 6 also shows the increase in size in terms of passenger capacity that has accompanied the speed increase. From a total of 15 passengers in the 1930 Ford Trimotor, the capacity has risen to about 70 at present in DC-7's and Constellations (varying from 60 to 80 depending on use in first-class or coach services) with prospects in the next generation of jet transports of going up to 130 or thereabouts in the Boeing 707 and the Douglas DC-8. This increase in size makes for improved aerodynamic efficiency (and therefore speed) and contributes to operational economies. Both are favorable to attainment of mass air transportation.

(4) *Short-haul transportation* services are the least tapped by the air lines. In the United States, there has been a steady and phenomenal growth in local service use, but the amount is small from the standpoint of a comparison with rail and bus in short-haul transportation. I have mentioned this before, and Table 1 depicts the present situation. It is included here under new traffic generation because, with the proper vehicle yet to be developed, a real change in city-suburb relationships might well come about. Suburban housing, for example, might move out from the distance bracket of 10–35 miles from city centers to a 35–100-miles distant bracket. This would create a potential increase of air usage of astounding proportions.

(5) All of these possibilities are, in the final analysis, dependent on technological advances based on fundamental and applied scientific research. That the needed progress will come about one has no doubt, fortified in so believing by the tremendous and ever-accelerating advances of the past years.

So far, we have concentrated on passenger travel. This is warranted by the preponderant position of passenger loads compared to mail, express, and freight. At present, the proportion of passengers in ton-miles compared to total pay load, including passengers, freight, express, mail, and any other is 85 per cent on the United States domestic trunk lines and 90 per cent on local service routes.

However, there are many persons who feel that a vast expansion in the transportation of cargo by air only awaits the appearance of aircraft suitably developed for this service (and probably designed with cargo transport exclusively in mind) coupled with appropriate effort to exploit the field. Past growth in the field makes available statistics which are really inadequate as a background for forecasting the future.

In Fig. 7, curves are drawn to show my own prognostication for expansion of the air transportation of freight and express for United States domestic and international air carriers. These lie somewhat above the forecasts made by the CAA but seem justified on the basis of considerations which parallel those advanced for passenger traffic, such as advantages in speed coupled with the potential of greatly reduced tariffs when specially designed cargo planes are available.

What about advances in technology? These have made themselves apparent in aviation to a marked degree, and there is no reason to believe that this will not continue to be the case in the future. The boundaries of scientific knowledge are being extended at an ever-increasing rate. From each new discovery numerous practical developments finger out—this whole process being one analogous to compound interest, a

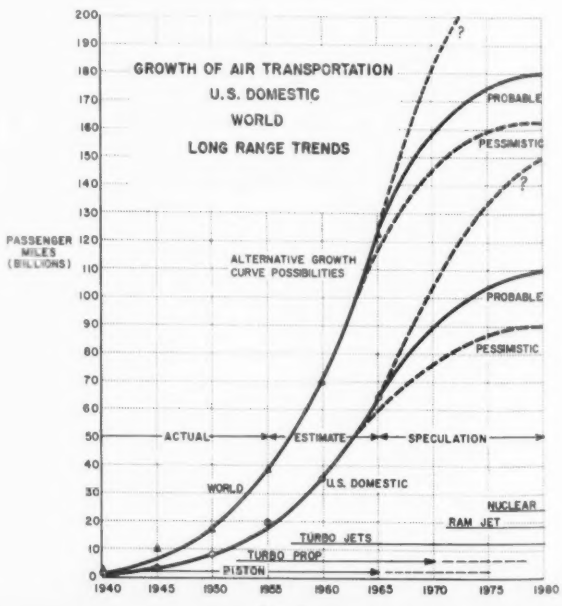

FIG. 8.

geometric progression. Science feeds on itself like a regenerative furnace to such an extent that a degree of advance that took 25 or even 50 years to occur a 100 years ago might well be expected to take place in 5 years now.

Conservatism and timidity persist in many areas of human affairs. But in the fields of the physical sciences and technology, at least, change and innovation are the rule. It takes considerable flexibility of mind to accept the concepts of the form that aircraft may have in the future, but there is no doubt that configurations which today appear strange and even weird will be accepted as usual at some future date.

It is the belief of the writer that gains in trip speed, reduction in land and concrete costs for airports having 10,000-ft. runways, and improvement in safety and, possibly, in noise at airports by getting its source away at steeper gradients will result in great development efforts exerted in their behalf and that the obstacles will be overcome. One could take an even further look ahead to missile mail carriers, satellite flights (not so far off), and even interplanetary air transportation.

Almost all developments, whether in business, in transportation, or in the technical field, advance along the classical growth curve. Starting slowly, such progress reaches a long period of steady growth, then tapers off, and is finally superseded by something better. Fig. 8 shows such a growth curve for aviation progress, in terms of air transportation, plotted against time. I would place us now near to the middle of the steep ascent. Hereon I have indicated some technical accomplishments encountered on the way. The shape of the curve is correct. The ultimate achievement must be considered conjecture, indicated by showing several branches representing the uncertainties in long-range forecasts. Although shown in terms of passenger-miles, it could be in terms of speed with Mach 2 in 1980. It is an inspiring vision.

Bibliography

Civil Aeronautics Administration, Staff Study, *Civil Air Traffic Forecasts*, August, 1955.

Air Transport Facts and Figures, 17th Ed., Air Transport Association of America, 1956.

Aviation Week Magazine, March, 1956.

Aviation Age Magazine, March, 1954.

Behold the Turtle, Shell Aviation News, June, 1956.

Economic Almanac for 1956, U.S. Conference Board, Business Fact Book, 1956.

Statistical Abstracts of U.S., U.S. Department of Commerce, Bureau of Census, 1954.

CAA Statistical Handbook of Civil Aviation, 1955.

Schairer, George S., *Economic Considerations of a Jet Transport Airplane*, Paper before Society of Automotive Engineers, January, 1955.

Aschenbeck, Lloyd B., *Passenger Air-Line Economics*, Aeronautical Engineering Review, Vol. 15, No. 12, pp. 39–43, December, 1956.

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Outline of a simple analytical technique useful in determining the cause of thermal cracking of turbine members.

An Analytical Method of Evaluating Thermal Stresses in Gas-Turbine Blades

William B. Sanders, Jr.,* and E. A. Trabant**
General Motors Corporation and Purdue University

Film Coefficient of Heat Transfer

An approximate range of values for the film coefficient of heat transfer may be determined by the following procedure.† The main assumptions embodied in the method are: (a) transition from a laminar to turbulent boundary is assumed to occur at a certain critical Reynolds Number; (b) compressibility effects are neglected in computing the coefficient and the local velocities; (c) the thermal properties of air are assumed for the working gas; and (d) coefficients for a flat plate and cylinder are amended to comply with the blade.

In essence, the method of obtaining the coefficient over a blade is to replace the leading edge by a cylinder and the remainder of the blade by a flat plate of length equal to that of the blade periphery. The cylindrical approximation is (see Fig. 1)

$$N_{Nu_D} = 1.14 N_{Pr}^{0.4} N_{Re_D}^{0.5} [1 - (\phi/90°)^3] \qquad 0 < \phi < 90° \quad (1)$$

For the remainder of the blade up to the transition, point, the flat-plate coefficient may be calculated by the formula

$$N_{Nu_x} = 0.323 N_{Pr}^{0.33} N_{Re_x}^{0.5} \quad (2)$$

The various lengths are shown in Fig. 2.

The transition from laminar to turbulent flow may be assumed to occur at the position, x_c, given by the equation

$$N_{Re_c} = u x_c \rho/\mu \quad (3)$$

An appropriate value for critical Reynolds Number is used here. An accurate assumption would be that the transition occurs at the point of minimum pressure. From the transition point to the trailing edge the following relationship is used:

$$N_{Nu_x} = 0.0315 N_{Pr}^{0.33} N_{Re_x}^{0.8} \quad (4)$$

In order to obtain numerical results from Eqs. (1), (2), and (4), it is necessary to adopt a procedure for determining the local velocities. For the purpose of obtaining preliminary values, the following simple method is suggested. A two-dimensional incompressible flow through an ideal lattice is assumed. Since the axial velocity must remain constant under these conditions, a vector diagram is constructed which gives the local velocity near the blade surface for a given profile.

To illustrate this method, note point "i" of Fig. 3 on the concave side of a blade. Assuming that the local velocity is tangent to the blade at this point and making an angle α with the axis of the turbine, the velocity is obtained from the diagram at the left of Fig. 3.

The heat-transfer coefficient at the stagnation point is obtained from Eq. (1) with $\phi = 0$ or

$$h = 1.14(k/D)\ (N_{Pr})^{0.4}(uD\rho/\mu)^{0.5} \quad (5)$$

Fig. 1. μ = viscosity, k = thermal conductivity, ρ = density; $N_{Nu_D} = hD/k$, $N_{Re_D} = uD\rho/\mu$.

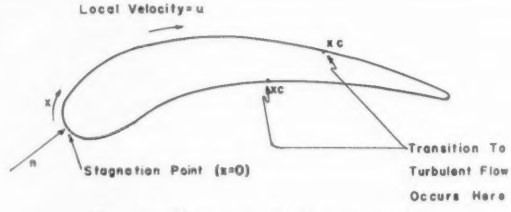

Fig. 2. $N_{Nu_x} = hx/k$, $N_{Re_x} = ux\rho/\mu$.

* Structural Stress Analysis Group, Allison Division.

** Associate Professor of Engineering Sciences.

† Westmoreland, J. C., *Determination of Viscosity of Exhaust-Gas Mixtures at Elevated Temperatures*, NACA TN 3180, June, 1954.

In this manner, it is possible to obtain an approximation to the heat-transfer coefficient along the convex and concave surfaces of a blade.

Temperature Distribution Equation

As a first approximation, temperature distribution may be found as a function of time and distance in a semi-infinite wall. The following argument may be offered to show that the calculations based on a semi-infinite wall lead to a temperature use which is less than the actual. The length of time it takes for the temperature to start rising at the point can be determined. After that time, the actual temperature will rise even faster than that calculated because the section L units thick can be considered insulated at the plane A-A by symmetry. (See Fig. 4.) On the other hand, the model used in the calculations is losing energy at this point.

Using the method of finite differences, the temperature at all times can be determined from the following recurrence relationships:

$$t_{n(x)} = e^{-\beta x}\{A_0 + A_1(2\beta x) + [A_2(2\beta x)^2/2!] + \ldots + [A_{n-2}/(n-2)!]\,(2\beta x)^{n-2}\} \quad (6)$$

$$t_{n+1(x)} = e^{-\beta x}\{B_0 + B_1(2\beta x) + [B_2(2\beta x)^2/2!] + \ldots + [B_{n-1}/(n-1)!]\,(2\beta x)^{n-1}\} \quad (7)$$

where

$B_r = -A_r + (1/2)\,(A_{r-1} + A_r + A_{r+1} + \ldots A_{n-2}),\quad 1 \le r \le n-2$

$B_0 = \{h[tg(T_{n+1}) + tg(T_n)] - A_0 h + k\beta(A_1 + A_2 + \ldots + A_{n-2})\}/(k\beta + h)$

$B_{n-1} = (1/2)A_{n-2}$

T = time

t = temperature

k = thermal conductivity

$A_0 = htg(T_2)/(k\beta + h)$

C = specified heat

$\beta^2 = 2\rho C/k\Delta T$

ρ = density

tg = gas temperature

Stress Distribution Equation

The following are the principal assumptions made in this analysis: (a) Material is homogeneous and isotropic. (b) Temperature is assumed to vary along the chord but not from root to top; as a result, the shearing stresses are considered constant on the surface of any longitudinal section. (c) The temperature is uniform in each section in which the blade is divided. (d) The blade is elastic. (e) For illustrative purposes, the longitudinal cross section of the blade is shaped either like a rectangle or trapezoid.

In using the method, a member is divided into several (r), long strips (Fig. 5), and starting from the leading edge (left edge) the sections are numbered consecutively. For continuity, the right edge of $(n-1)$ must have the same length as the left edge of section n after all deformations are considered. In a similar manner, the right edge of section n must have the same final length as the left edge of section $(n-1)$. This condition is true throughout the member. Similarly, the total shearing load on the right edge of section $(n-1)$ must equal the total shearing load on the left edge of section n, etc. For section 1, the shearing force $Q_{n-1} = Q_0$ must equal zero. For section r, the last section, $Q_n = Q_r$ must equal zero also. These are the boundary conditions. Using these, all the Q_n's in the member can be evaluated.

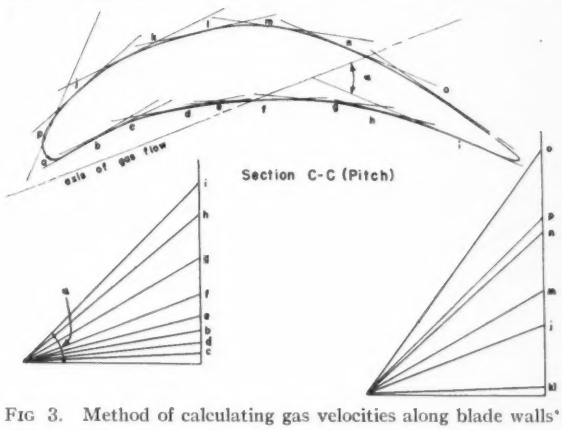

Fig. 3. Method of calculating gas velocities along blade walls

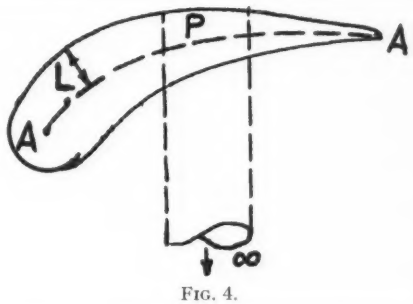

Fig. 4.

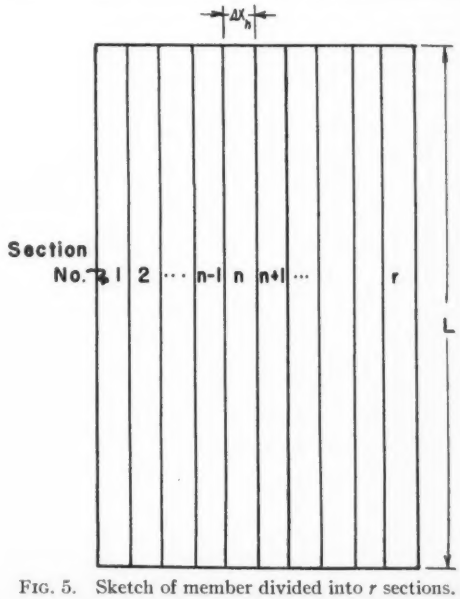

Fig. 5. Sketch of member divided into r sections.

The following recurrence relation is obtained for the shear forces:

$$\Delta_n Q_{n-1} - \mathfrak{L}_n Q_{n-2} + \zeta_n = 0 \tag{8}$$

where

$$\begin{aligned}
\Delta_n &= \Delta_{n+1} A_n - \mathfrak{L}_{n+1} \\
\mathfrak{L}_n &= \Delta_{n+1} B_n \\
\zeta_n &= \zeta_{n+1} + \Delta_{n+1} C_n \qquad (9) \\
\Delta_r &= A_r, \quad \mathfrak{L}_r = B_r, \quad \zeta_r = C_r \\
A_n &= (\alpha_n + \alpha_{n-1} + B_n + B_{n-1})/\alpha_n \\
B_n &= \alpha_{n-1}/\alpha_n \\
C_n &= (e_{tn} - e_{tn-1})/\alpha_n \\
\alpha_n &= LH_n/[2(h'_n + h_n)\Delta x_n E_n] \qquad (10) \\
\beta_n &= [4(1 + \nu)\Delta x_n]/[E_n L(h_n + h'_n)] \\
e_{tn} &= \delta L_n(t_n - t_{ni}) \\
H_n &= [h'^2_n - h_n^2 - 2h_n^2 \ln (h'_n/h_n)]/(h'_n - h_n)^2 \\
h_n &= \text{thickness of section } n \text{ at tip} \\
h'_n &= \text{thickness of section } n \text{ at root} \\
L &= \text{length of member measured radially} \\
e_t &= \text{elongation of section caused by temperature change} \\
\Delta x &= \text{length of section measured along chord} \\
\delta &= \text{coefficient of thermal expansion} \\
t_i &= \text{initial temperature of section} \\
E &= \text{modulus of elasticity} \\
\nu &= \text{Poisson's ratio}
\end{aligned}$$

Repeating Eq. (8) until n is reduced to 2 gives

$$\Delta_2 Q_1 - \mathfrak{L}_2 Q_0 + \zeta_2 = 0 \tag{11}$$

but $Q_0 = 0$, so $Q_1 = -\zeta_2/\Delta_2$

and $A_n Q_{r-1} - B_n Q_{r-2} + C_n = 0$

then
$$\left.\begin{aligned} Q_2 &= A_2 Q_1 + C_2 \\ Q_3 &= A_3 Q_2 - B_3 Q_1 + C_3 \end{aligned}\right\} \tag{12}$$

In this manner all the shearing forces acting on the edge of the sections can be evaluated.

The normal stress in the leading edge is assumed to be that in section 1. By dividing the shear load at any n section normal to the radius by the cross section n at that point, the normal stress can be determined. Thus, the normal stress at the root of the blade is

$$\sigma_1 = -Q_1/\Delta x_1 h_1 \tag{13}$$

For section 2, this stress is

$$\sigma_2 = (Q_1 - Q_2)/\Delta x_2 h_2 \tag{14}$$

and so forth. Where the thickness of the blade varies along the chord, h_m is taken as the mean thickness of the section at the radial location desired.

Numerical Analysis

Numerical solutions for three different shapes were made to determine the effects of these parameters on the stresses in the leading edge. Using eight sections, solutions were found for (1) a flat plate; (2) a member having a trapezoidal cross section normal to the chord but holding this cross section constant for each section; (3) a member where the cross section normal to the chord varies for each section and is rectangular in shape but using a blade profile.

In all of these cases, the temperature distribution along a chord was kept the same with a length L_n, of 3 in., a modulus of elasticity of 28×10^6 lbs./in.^{2}, and a coefficient of thermal expansion of 7.5×10^{-6} in./in./°F. The temperatures used were computed using the described methods and were the average of the surface temperatures for the opposite concave and convex surfaces of each section.

(1) Flat plate: $\sigma_1 = 125{,}750$ psi, compression.

(2) Tapered section: $\sigma_1 = 114{,}700$ psi, compression.

(3) Profile variation: $\sigma_1 = 143{,}760$ psi, compression.

These values indicate that tapering the longitudinal cross section of the blade tends to decrease the thermal stress in the leading edge. On the other hand, increasing the thickness of the blade along the chord from the leading edge tends to increase the thermal stress in the leading edge. Hence, tapering the longitudinal cross section of the blade and moving the thick section of the blade away from the leading edge tend to decrease the thermal stresses in the leading edge.

It is recognized that the given values are above the yield point and further analysis is necessary in view of this condition.

Bibliography

Jacob, M., *Heat Transfer—Volume I*, John Wiley & Sons, Inc., New York, 1949.

Eckert, E. R. C., *Introduction to the Transfer of Heat and Mass*, McGraw-Hill Book Company, Inc., New York, 1950.

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A discussion of the need to establish design criteria for all systems of the modern aircraft—guidance and control, stability, propulsion, etc.—in order to be able to relate them to the structural criteria and a proposed method and organization for new criteria development.

A New Look at Aircraft Design Criteria

Arthur T. Clemen*
Convair, A Division of General Dynamics Corporation

Introduction

Man has been having trouble with criteria ever since Adam and Eve partook of the apple and acquired a criterion for knowing good from evil. Since then man has spent a major portion of his time inventing, using, avoiding, and, finally, changing criteria of one sort or another. That last participle, *changing*, is significant for it is the one that produces progress.

We are all familiar with law, customs, traditions, religion, supersitition, etc. These are all criteria in various forms—that is, they are rules or measures we use as standards of judging. But, if we look at history, we find that these "criteria" have been continually changing since the dawn of man.

The main reason seems to be that, whether we like it or not, the *status* simply will not stay *quo* for very long. Events seem to proceed smoothly for a time according to a certain set of rules or criteria. But during this time, people, technology, the weather, and a lot of other things are gradually changing. Finally it develops that the old rules do not seem to work very well under the prevailing circumstances. So somebody manufactures a new law, or custom, or belief, as the case may be. The main justification for the change is that the new criterion works, or some one thinks it will work, better than the old one.

Perhaps we need a new approach to aircraft design criteria.

Current Design Criteria Practice

It is well known that most of our modern aircraft can no longer be designed successfully by the exact recipes set down in the existing criteria. This is nobody's fault. In fact it is rather to be expected since we are continually outrunning the state of the art. But we still try to design by rules of thumb and past experience instead of to logical criteria tailored to each specific project.

Only for structural design do we regularly set down a specific set of criteria sometime during the early phases of a design. There was a time when such criteria were all that was necessary. Aircraft were designed merely to fly and to hang together under whatever loads pilots could impose on them. The structural design criteria determined almost completely the capabilities and effectiveness of the aircraft.

Need for More Complete Criteria

Although the structural design criteria are still very significant factors in the design, they are by no means as comprehensive as they once were in determining overall weapon system effectiveness measured in terms of mission accomplishment. Other factors such as guidance and control systems, environmental control, stability, and propulsion systems have vast effects on the ability of the vehicle to accomplish its mission. Yet we rarely begin at the inception of a project to set down design criteria for these other areas and relate them early in the design to each other and to the structural criteria that we do write.

The Problem

We appear to be in a situation similar to that of Kipling's Ethiopian who decided that it was "high time for a change." He proceeded to change both his surroundings and his skin and, thereby, the rules and techniques by which he lived. It might behoove us to do likewise.

Let us consider the only criteria we now develop and use as such—the *Structural Design Criteria.*

The existing structural design criteria are based primarily on past experience and conservative estimates of what were thought to be future requirements when these documents were written. They represent the best available information and thinking of their time and are excellent guides to the design of the type of aircraft with which the writers were familiar. However, the pace of technological development has been accelerating

* Project Structures Engineer, Fort Worth.

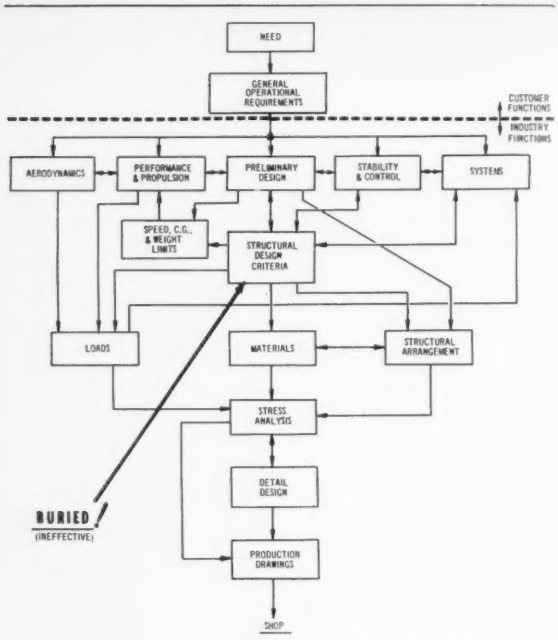

FIG. 1. Typical present information flow (approximate and simplified).

so rapidly that almost every new aircraft represents a step into the unknown. This is especially true of missiles. Thus many of the design requirements set forth in the current official criteria cannot be expected to be adequate for most of the new designs.

In large measure the structural design criteria problems arise because many of the new aircraft configurations are, to say the least, somewhat different from what was formerly regarded as conventional. There are also problems involving Mach Number, temperature, dynamic response, and even nuclear radiation which were unheard of a few years ago. Obviously the use of design maneuvers, control deflections, gust velocities, and ultimate factors of safety which were reasonable, though often arbitrary, for past designs will not necessarily be reasonable or adequate for future designs.

The problems outlined above have been encountered in many of the current designs. Thus far the solution has been effectively to rewrite existing specifications for each new design. Specification changes are requested as their necessity becomes evident. This always involves endless argument and many formal deviations from existing specifications, not to mention a substantial cost in time and money. In general the Services are to be commended for their willingness to accept reasonable and necessary deviations and to encourage investigations leading to changed criteria. But the Services are caught in the same mill as the rest of us, only more so. They are in the unenviable position of being charged on the one hand with the responsibility of seeing that the taxpayer gets his money's worth and on the other hand with not being daring enough in their approach to technical problems. It appears desirable, then, to arrive at a solution to the problem which will benefit both the customer and the contractor and promote the advancement of the state of the art.

A Proposed Solution

The proposed solution is simply this: Change the philosophy of the generation and use of design criteria. Accept the fact that most future aircraft will require individual design criteria tailored to their mission requirements. We should not be bound unnecessarily to previous criteria and forced to spend much time and money justifying deviations. In addition we should organize our preliminary design efforts in such a manner that reasonable and adequate criteria can be generated at the inception of a design and be continuously evaluated and revised as the design progresses.

Advantages of the Proposed Solution

What would be the advantages of such an arrangement?

First, more profound thinking would have to be done in the initial stages of a design than is generally done now. This effort would be directed toward the definition of an operational philosophy for the aircraft. Once the operational philosophy and mission were defined, the design criteria could be written based on the specific requirements of the particular project. The operational philosophy and the criteria would then constitute the ground rules, basic data, and techniques to be used in design. Since there would be fewer customer-specified or arbitrarily imposed criteria, a more rational approach to the requirements of each project would necessarily result.

A second advantage would be the elimination of costly deviations from existing documents. This is not to say that all Government criteria should be eliminated completely. Rather they should be written in more general terms than is currently the case. Thus there would be no specific or detailed requirements against which deviations would have to be written. The experience and thought represented by the present criteria documents could be set up as supplements to the basic general criteria. Parts or all of these supplements could be used when judged applicable by the contractor.

A third advantage would be the more efficient integration of ground rules for the entire project due to early centralized generation of operational philosophy and criteria.

Implementation of the Proposal

It is one thing to present a theory but often quite another to translate the theory into practice. We have suggested that a new approach to the problem of generating design criteria is needed. Now, how do we implement the new approach?

Again we will use the *Structural Design Criteria* as our example. Fig. 1 is an approximate information flow diagram of the typical situation surrounding the structural design criteria. The significance of the diagram

lies in what it does *not* show rather than what it does show.

Two things are immediately apparent from Fig. 1:

(1) There is no central unified source of information on operational philosophy, design criteria, ground rules, or basic data.

(2) A lot of analysis and design work is apt to be done before the structural design criteria are written because the criteria function is buried in the overall operation. Even when it is written, it often turns out to be a *result* of the analytical and design work instead of a *cause* of it.

A suggested revised information flow diagram is shown in Fig. 2. In this diagram an operational philosophy is the first result of a need for a certain type of aircraft. The design criteria have been exhumed and are the direct outgrowth of the operational philosophy. Subsequent design work follows from the ground work laid down by the operational philosophy and the design criteria. Such an arrangement lends itself to the inclusion of more than strictly structural considerations in the design criteria. This is extremely desirable because such matters as navigation or guidance system accuracy and reliability, warhead size, control system resolution, and power-plant characteristics can have a marked influence on the structure and on each other, as well as on the success of the vehicle in carrying out its mission. In the final analysis, maximum mission reliability and effectiveness are the design goals.

The type of information flow shown in Fig. 2 probably does not now exist in any organized form because it has not previously been necessary. Present organizations have simply grown into the type shown in Fig. 1 because it has in the past been possible and practical to separate functions into specialties. Until recently there was not too much overlap. In the future, however, it will be increasingly more necessary to provide conceptual and functional integration at the very beginning of a project in order to prevent design chaos.

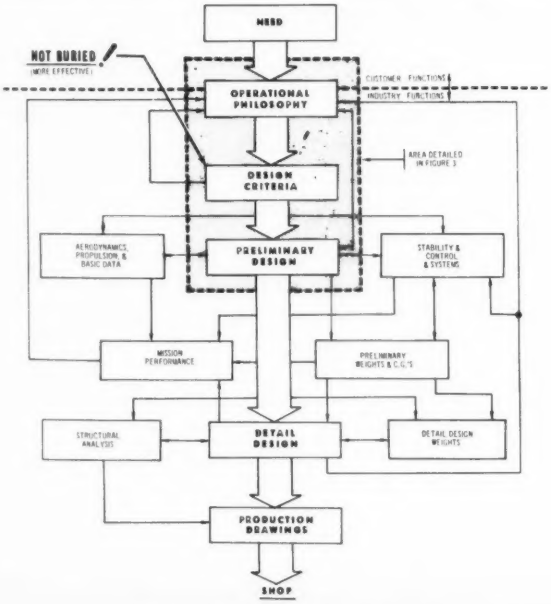

FIG. 2. Proposed information flow.

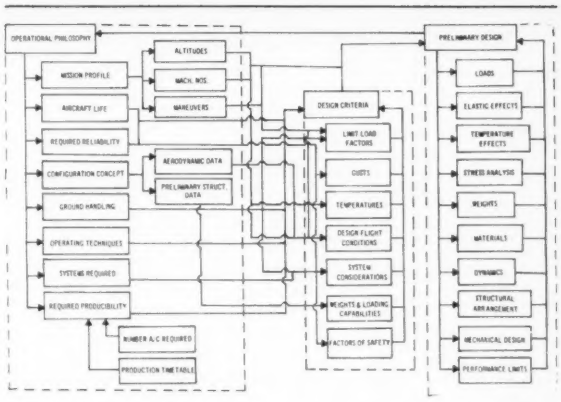

FIG. 3. Partial detail of information flow in area outlined in Fig. 2.

A more detailed breakdown of typical functions that should be performed by the Operational Philosophy, Design Criteria, and Preliminary Design units is shown in Fig. 3. When it is realized that any one of the functions or blocks shown in Fig. 3 represents a formidable problem in its own right, it becomes apparent that a haphazard approach will no longer do the job. Life in the aircraft factory is becoming complex. Fig. 3 is not intended as an organization chart or even as a complete information flow chart. Its purpose is simply to show graphically some of the complications involved in current designs. There are in reality many more inner feedback loops than are shown. It is apparent, however, that the generation of design criteria has become an exceptionally involved process requiring the consideration of many interacting factors. All of the various requirements must be correlated and condensed into a relatively simple set of rules and criteria that can be used for design.

In order to accomplish its purpose most efficiently, the design criteria should be available, at least in rudimentary form, early in the design process. This can be done only if the people responsible for determining the criteria are made cognizant of the problem at the very beginning. They must be familiar with the reasons behind the need for the aircraft, its intended use, the timetable involved, etc. In short they should be familiar with the whole background of the project at the earliest possible moment in order that they may be in a position to correlate the multitudinous considerations properly.

In practice it will probably be found advisable to have all, or at least some, of the same people generate both the operational philosophy and the design criteria. Continuity of thought can thus be maintained from inception to detail design. In addition these people should monitor the project as it progresses in order to ensure the desired relationship between the initial statements of need, the operational philosophy, and the end product.

(*Continued on page 63*)

Use of a hot platinum-wire combustibility detector in a continuous sampling process, providing measurement of the per cent of the lower explosive limit of mixtures at concentrations well below the lower explosive limit.

Design of an Apparatus for the Measurement of the Combustibility Hazard of Gases in Aircraft and Other Applications

Enoch J. Durbin*
Princeton University

Introduction

This paper is concerned with the discussion of a method for designing an apparatus for the detection and measurement of explosive gases occurring in various military, aeronautical, and industrial processes. The explosive danger associated with the presence of fuels, hydraulic fluids, gun and engine exhaust gases, industrial process gases, mine gases, and other combustibles has received considerable attention in the past and has been the subject of research of many investigators in many fields. The problem has become particularly severe in modern aircraft because of the need for storing huge quantities of highly volatile fuels in the vicinity of hot engines or near a prodigious number of electrical devices, each of which can provide many potential sources of ignition to any stray explosive mixture.

Many physical and chemical methods for the detection of explosive gas and vapors have been developed. Some of these involve the measurement of (a) the change in pressure or volume of the sample when burned, (b) the reaction of the unknown sample on a catalyst involving a change in the physical characteristics of the catalyst such as electrical resistance or luminosity, (c) chemical reactions occurring between the combustible gas and various chemical compounds, and (d) the thermal conductivity of the gas.

The work on the apparatus to be described here was restricted to providing a method for continuously sampling potentially explosive gases and vapors in aeronautical and industrial installation and for continuously measuring the combustibility of these potentially explosive gases with a view toward providing a warning as the combustibility approached a dangerous condition—in addition to providing a method of measuring the effectiveness of ventilating systems or other safety devices intended to reduce this explosive hazard.

An adequate combustion hazard monitor must be capable of detecting and measuring explosive mixtures which are well below the lower explosive limit of these mixtures. The lower explosive limit of any combustible gas is the minimum percentage of combustible gas in homogeneous mixture with air which will propagate a flame when exposed to a suitable source of ignition. If measurements can be made of this combustible gas at concentrations below the lower explosive limit, the build-up of dangerous concentrations can be charted and remedial action taken.

Ideally, a safety monitoring apparatus should utilize a characteristic of the phenomena being monitored which is directly related to the hazard-producing event rather than to some indirectly related characteristic. This is important in order to prevent some unusual combination of events from masking a hazardous condition. For example, a device which depends on the color of a gas for indicating toxicity might fail completely in the presence of a nontoxic, colorful gas.

A safety monitoring apparatus should be capable of detecting changes in the nature of a gas within a time which is at least as short, or shorter, than the time required for the dangerous condition to develop. Hazardous conditions associated with modern fuel and gun exhaust gases can have rates of combustible gas build-up which are quite rapid, sometimes occurring within several seconds. It has been reported that, in some gun installations in aircraft, the build-up of combustible gun exhaust gases has occurred in fractions of a second. Since the factors affecting this rapid build-up are not always clearly predictable, an important requirement of a successful apparatus would be to provide a continuous monitor of these conditions.

* Senior Research Associate, Department of Aeronautical Engineering; also Consultant to Hunter-Bristol Corporation.

Many devices have been developed in the past for the detection and measurement of combustible vapors and gases. The most successful of these have all been based on the same principle: An electrically heated platinum filament can become catalytic in the presence of many combustible gases and can cause a reaction between the constituents of the vapors at temperatures well below the normal ignition temperature of the vapor and at concentrations well below the lower explosive limit. There are many advantages in using this principle. It can be used to create an effect which will occur before the vapors have reached the point where explosive conditions are present, thus satisfying the first condition mentioned previously. The use of the electrically heated platinum filament satisfies the condition that the measurement be directly related to the source of the hazard. Since the vapors are actually ignited on the surface of a catalytic filament, the reaction which occurs is identical to the reaction which occurs in an explosion. The time delay of the actual reaction is infinitesimally small, the major delay being in the time required to draw the sample from the area under study to the test apparatus. This time, however, can be easily controlled since it depends on the inner diameter of the sampling tube, the length of the sampling tube, and the flow rate through the sampling tube. Each of these factors can easily be varied over a wide range of values.

It is clear then that, in principle at least, the use of a heated platinum filament as a basic sensing device for combustible vapors satisfies all the general requirements of an adequate safety hazard monitor. There are, however, certain limitations and problems associated with the use of this phenomena, and it is these problems which are discussed in the next section of this paper.

The Hot-Wire Combustibility Detector

The idea of using the principle of a hot-wire combustibility detector as a means of measuring gas concentration is quite old and had reached a high stage of development as early as 1912 as shown by a British patent granted that year. The slow development from that time on was probably caused by insufficient knowledge of the behavior of the catalyst and of the difficulty in manufacturing fine, uniform, homogeneous platinum wires and in providing a simple reliable measuring apparatus.

Many of the devices which had been developed to date using this principle have certain features, inherent in their design, which make them far from satisfactory tools in solving aeronautical and industrial problems associated with the hazards of the handling of combustible gases. Most of these deficiencies are related to variation of the calibration of these devices with temperature, humidity, pressure, and aging of filaments. The reason for these variations is clear when the mechanism of the technique which has been employed is understood.

If a combustible gas is mixed with a suitable oxidizer and is introduced into a chamber containing a heated platinum filament, it is possible to produce combustion at the surface of the platinum wire at temperatures well below the ignition temperature of the gas mixture. This reaction takes place right at the surface of the heated wire. At low concentrations and at high flow rates, much of the heat of combustion goes toward raising the temperature of the unburned gas. The rise in temperature of the wire is a function of the heat of combustion of the gas, the per cent of combustible gas in the mixture, and the heat capacity of the wire.

Sensing the Combustion

The change in the electrical resistance of the heated wire due to the burning of the combustible gas which takes place on the surface of the wire can be used as a measure of the heat of combustion of the gas mixture quite conveniently, provided that either all the heat of combustion goes into the raising of the temperature of the wire, and thereby its resistance, or that the portion of the heat of combustion which does not go into elevating the temperature of the wire is a constant amount or is known.

Many experimental studies have been made of the filament temperature versus combustible gas concentration relationships. It has been found that, if a suitable source of a combustible gas mixture, such as propane and air, is supplied to a cell containing a platinum filament heated electrically to a temperature which is less than approximately 200°C., no increase in filament temperature occurs as the proportions of propane and air are changed. However, if the initial temperature is raised to 300°C., it is found that the temperature varies linearly with the percentage of propane in air of the mixture until the lower explosive limit is reached. Above the lower explosive limit the rate of increase decreases until the point of maximum flame propagation is reached. Beyond this value of combustible gas the temperature starts to decrease. As the temperature of the filament prior to the introduction of the combustible gas is raised beyond 300°C., the slope of the curve of combustible gas versus filament temperature characteristic increases until a temperature of about 350°C. or 400°C. is reached. Beyond this temperature no further increase in slope occurs. These observations, however, are true only if the mass flow through the cell or sensing device is held constant while the various changes described above are being made.

It should now be recalled that the change in electrical resistance of a platinum conductor due to a change in temperature T is given approximately by the following type of equation over a very wide temperature range of at least 1,200°C. (i.e., from −200°C. to +1,000°C.):

$$R_T = R_0 [1 + A (\Delta T) + B (\Delta T)^2]$$

where R_T is the resistance at a given temperature, R_0 is the resistance at 0°C., and A and B are constants.

Over the much smaller range of temperatures which

are of concern in the platinum-wire combustibility detector, this equation can be replaced, with only very small error, by

$$R_T = R_i (1 - C\Delta T)$$

where R_i is the resistance of the wire before the introduction of combustible gas and C is the average slope of the resistance versus temperature curve over the temperature range of interest.

This simple relationship permits one to take advantage of the previously mentioned fact that, above a certain minimum temperature, the slope of the curve of the per cent combustible gas versus change in temperature of the catalytic platinum wire is constant. It is customary to measure small changes in electrical resistance by means of bridge circuits. In the usual resistance bridge circuit, the electrical output voltage is proportional to the voltage applied to the bridge and to the ratio of the change in resistance of the arms of the bridge to the initial resistance value of the bridge arms, provided that the changes in bridge resistance are small. This ratio of change in resistance to initial resistance can be written from the previous equations describing the change in resistance due to changes in temperature. The output voltage of a resistance bridge due to a temperature change of T, when a constant input voltage of E_i is applied, can then be written as

$$E_{out} = E_i C R_i \Delta T / R_i = E_i C \Delta T$$

where E_{out} is the bridge output voltage. (C and R_i have been defined previously.)

It is clear then that the output is not a function of the initial bridge resistance. Thus, if the initial wire temperature is sufficiently high to permit the sensing device to operate in the nonchanging slope region, the bridge output can be made independent of the initial gage temperature. This permits a great simplification in the design of an apparatus for sensing combustible gases by means of a heated platinum wire. It indicates that, if the measuring voltage applied to the bridge is held constant and the bridge is balanced to give zero output at zero combustible gas, the calibration of the apparatus will be independent of the initial gage temperature and that this initial gage temperature needs to be greater than some minimum value but its value does not have to be otherwise exactly specified.

This relationship permits a further important simplification and improvement in calibration stabilization. If the voltage E_i mentioned above is provided from a constant voltage source rather than a constant current source, then the output of the bridge will be independent of aging effects of the sensing element which tended to change its resistance. This voltage source would be considered constant if the source impedance were such that the change in bridge resistance would result in no significant change in the input voltage to the bridge.

The relationship between the concentration of combustible gas, the temperature of the wire, and the change in resistance of the wire permits a simplified scheme for checking the calibration of the platinum hot-wire apparatus. It had been noted that, beyond a certain minimum temperature, the increment in temperature of the hot wire due to a given concentration of combustible gas is a constant and the resistance versus temperature curve of the hot wire is quite linear over a wide range of temperature. It appears, then, that calibration of such an apparatus might be accomplished by insertion of a resistance into one arm of the bridge to simulate a given combustible gas concentration, provided that this resistance value is a fixed proportion of the resistance of the bridge arms rather than a fixed value. A necessary accessory in the use of Wheatstone bridge-type devices is a bridge balance scheme, which incidentally can be used to provide a measure of the resistance of the arms of the bridge. A logical consequence of all these factors is to have two potentiometers ganged together on a common shaft such that, as the first potentiometer is varied to balance the bridge, the second is varied proportionately to provide the desired calibration resistance.

Pressure Effects

There are two main effects which are related to changes in ambient pressure and which result in apparent calibration changes in an apparatus designed to indicate combustibility of a mixture. These will be discussed here.

The first effect is due to the fact that, with most inflammable gas/air mixtures, a reduction in pressure from sea-level atmospheric leads to a narrowing of the inflammability range—that is, the per cent of combustible gas required to reach the lower explosive limit increases with reduced pressure while the per cent of combustible gas required to reach the upper explosive limit reduces until, at some suitable low pressure, the lower and upper limits of inflammability coincide. At still lower pressures there is no mixture of combustible gas and air which will explode. This low limiting pressure is called the explosion limit. There are some mixtures of gases which have an upper as well as a lower explosion limit, the upper explosion limit referring to a maximum pressure beyond which combustion cannot take place.

This change in lower explosive limit, with pressure, results in a reduction of explosion hazard in aircraft flying at higher altitudes. It also indicates that an apparatus which is designed to monitor the per cent of lower explosive limit of a given mixture will indicate different readings at different altitudes. These will, at first glance, appear to be calibration changes but will, in reality, merely reflect a true change in the lower explosive limit. Clearly then, in an experiment which is designed to study combustibility hazards, recognition must be given to this variation of combustibility with pressure. In aircraft applications, this would indicate that tests conducted at the lowest operational altitudes will indicate conditions of maximum hazard due to a given combustible gas concentration. However, the concentration of the combustible gas will surely vary

with changing atmospheric pressure due to the change in effectiveness of ventilating systems and to the increase in vaporization when these combustible gases are vapors of liquid fuels. In a series of experiments on the explosibility of gun exhaust gases, it was found that there was a 50 per cent increase in the per cent of combustible gas required to reach the lower explosive limit at 40,000-ft. altitude when compared with the per cent of combustible gas required to reach the lower explosive limit at sea level. In experiments with mixtures of hydrocarbon gases and air, the lower explosion limit has been found at pressures corresponding to altitudes of approximately 45,000 ft. At altitudes greater than this, flame propagation could not be induced.

The second pressure-related effect which causes a change in calibration of a platinum-wire combustibility detector is due to a change in the factors which affect the heat losses from the hot wire at a temperature of about 350°C. (approximate operating temperature of the wire). The first process by which heat is removed from the wire is a convective one. Heat loss by this convective process is a function of wire dimensions, difference in temperature between the wire and the flow in gas, the velocity of the gas, and its density and time. Noting that it is only necessary to stabilize heat losses from the wire to stabilize the calibration, the method of controlling these heat-loss factors becomes clear. If the temperature of the gas and the mass flow through the test chamber are held constant, the convective heat losses will be stabilized. If the mass flow through the chamber is made small as well as held constant, then the heat losses will be both stabilized and small.

Both of the pressure-related effects mentioned above can be controlled by a very simple scheme. If a pressure regulator upstream of the platinum-wire test cell, the test cell, and a sonic orifice downstream of the cell are all placed in a temperature-controlled location and if these are then connected to a vacuum source which is capable of maintaining sonic flow through the orifice, the pressure-related conditions causing calibration variation will all be eliminated. The use of a pressure regulator will make the experiment independent of altitude. The temperature-controlled area will maintain the gas at a constant temperature. Lastly, since the mass flow through an orifice is only a function of upstream pressure, if the flow is sonic, the orifice can provide a constant mass flow provided that the vacuum source can maintain a pressure downstream of the orifice which is less than half the regulated upstream pressure. Since the flow in an apparatus such as is described here would usually be quite small, this is easily attained.

There are certain cautions which should be noted in the design of an apparatus using the above techniques for stabilizing calibrations. (1) The pressure at which the regulator is set must be lower than the lowest pressure which will be encountered during the experiment by an amount at least as great as that required by the regulator to operate. (2) This pressure must be above the lower pressure explosion limit. If this condition is inadvertently not satisfied, the apparatus would never indicate a hazardous condition regardless of the amount of combustible gas. This is clearly a very dangerous situation.

Filament Poisoning

A potential source of gross error in an apparatus for detecting combustible vapors by the heated platinum-wire method is due to effects which are usually called filament poisoning. This term refers to the fact that the presence of certain gases or vapors causes the filament to lose its catalytic property.

Such poisoning, for example, may take place on platinum filaments used for the detection of vapors produced by petroleum products containing tetro ethyl lead, such as most high-octane automobile and aviation gasolines. The cause of this so-called poisoning seems to be due to the formation of a thin coating over the platinum filament so that the filament is unable to come into intimate physical contact with the combustible gas. Since the effect of such a coating is to make the apparatus indicate concentrations of combustible gas which are less than actual, care must be taken to minimize filament poisoning possibilities. The use of fine-mesh filters can help reduce this effect, but the only positive indication of "no poisoning" can be a calibration check after exposure to poisoning vapors. There appears to be very little poisoning agent in modern jet-engine fuels.

Safety

Since the hot-wire method results in combustion occurring in the detector unit, some words concerning the hazard involved in this process are in order.

It has been previously noted that the reaction at the surface of the heated platinum filament takes place at a temperature which is well below the ignition temperature of a gas. Because of this, the initiated combustion will not generate sufficient heat to raise the temperature of the adjacent layers to their ignition point. Further combustion will only take place with those molecules of gas which come into contact with the platinum surface. However, as an added precaution, it is possible to install a flame arrestor at the inlet to the sensing chamber. This can consist of a fine wire screen which then serves the double purpose of being both a filter to minimize filament poisoning and a flame arrestor.

Combustion Properties of Inflammable Gases

For each combustible gas or vapor mixed with air, there is a particular mixture at which there is just sufficient oxygen to complete combustion. At this concentration, the gas/air mixture generates the maximum quantity of heat, the value of which can be calculated from the known heat of combustion per mole and the per cent of combustible gas in the mixture. Similarly, the heat of combustion at conditions corresponding to the lower and upper inflammable limits can be calculated.

TABLE 1

Some Combustion Properties of Petroleum Hydrocarbons

Hydrocarbon	Methane	Ethane	Propane	Butane	Normal Pentane	Iso-pentane	Hexane	Heptane	Octane	Nonane	Decane	Uno-decane	Duo-decane
(1) Molecular formula, C_nH_{2n+2}	CH_4	C_2H_6	C_3H_8	C_4H_{10}	C_5H_{12}	C_5H_{12}	C_6H_{14}	C_7H_{16}	C_8H_{18}	C_9H_{20}	$C_{10}H_{22}$	$C_{11}H_{24}$	$C_{12}H_{26}$
(2) Molecular weight, $14_n + 2$	16	30	44	58	72	72	86	100	114	128	142	156	170
(3) Heat of combustion, kg.-cal./mole	213	373	530	688	845	838	1,002	1,159	1,316	1,473	1,630	1,787	1,944
(4) Lower inflammable limit, % by vol.	5.00	3.22	2.37	1.86	1.40	1.32	1.25	1.00	0.95	0.83	0.70	0.67	0.62
(5) Mixture giving maximum heat on combustion, % by vol.	9.50	5.68	4.03	3.13	2.56	2.56	2.16	1.87	1.65	1.48	1.34	1.22	1.12
(6) Upper inflammable limit, % by vol.	15.00	12.50	9.50	8.40	7.80		6.90	6.00					
(7) Heat of combustion at lower inflammable limit, kg.-cal./mole	10.65	12.01	12.56	12.80	11.83	11.07	12.52	11.59	12.50	12.23	11.40	11.97	12.05
(8) Maximum heat of combustion, kg.-cal./mole	20.25	21.20	21.35	21.52	21.64	21.46	21.64	21.68	21.72	21.81	21.85	21.81	21.82
(9) Heat of combustion at upper inflammable limit, kg.-cal./mole	19.00	19.65	20.20	20.30	20.50		20.60	20.80					

These two values are compared in Table 1 for a wide variety of petroleum hydrocarbons. Some very interesting observations can be made from this table which are of great value in helping to understand the possible applications of an apparatus based on the hot-wire principle. From the table, it will be noted that, for all practical problems, the heat generated by each of the petroleum hydrocarbons at its lower inflammable limit (line 7) is constant. Similarly, the maximum heat of combustion (line 8) and the heat generated at the upper inflammable limit (line 9) are constant within experimental limits of error.

When it is noted that the determination of the lower inflammable limit is a rather complex process experimentally, the close agreement between the many hydrocarbons is indeed remarkable. Such variations, as is indicated in the table, can be readily explained by the difficulty in observing the movement of a flame during inflammability limit tests. This is especially true over the wide variations in molecular weights of the gases shown in the table. Gases which have a high thermal conductivity and a low density tend to dissipate their heat much more rapidly than gases having a low thermal conductivity and a high density. It would appear most reasonable to assume that mixtures of these petroleum hydrocarbons would also give heats of combustion at the lower, upper, and maximum explosive limits of the mixture similar to those shown in the table. This has been proved by means of experiments with these mixtures. Now what does all this mean in terms of a combustible gas detector of the hot-wire type? Since the change in resistance of the hot wire is proportional to the heat generated for combustion if the heat capacity of the wire is constant and if all of the heat of combustion serves to raise the temperature of the wire, Table 1 offers some very interesting possibilities to the experimenter who is interested in determining the presence of a hazardous condition but who is not certain as to the exact constituents of the combustible mixture. A hot-wire apparatus which has been calibrated to read in terms of per cent of the lower explosive limit for one of the petroleum hydrocarbons will read, in the presence of other petroleum hydrocarbons and mixtures thereof, correctly with a very small error. For example, measurements at the lower explosive limit of various petroleum hydrocarbons made with a hot-wire apparatus which had been adjusted to read 1.0 for butane gave readings of 1.0 for propane, pentane, hexane, and 100-octane aviation gasoline and 0.99 for 87-octane aviation gasoline. The agreement between all these values is indeed remarkable. The possibility of a universal type of calibration is not limited to petroleum hydrocarbons solely but has been found to apply, with reasonable agreement, to such combustibles as carbon monoxide and such mixtures of carbon monoxide and hydrogen as are found in exhaust gases of guns.

In order to take maximum advantage of these observations in the similarity between the various combustibles in heat of combustion at the lower explosive limit, an apparatus should have an indicator which is calibrated to read as a fraction of the lower explosive limit rather than heat of combustion or some other unit. If the apparatus employs the pressure and flow control scheme mentioned previously, the indicator can be calibrated to read per cent of the lower explosive limit at some pressure or altitude.

CONCLUSIONS

An apparatus for measuring the concentration of a combustible gas as a proportion of the concentration required to reach the lower explosive limit has been designed utilizing the ideas presented here. It has provision for maintaining a constant mass flow through the

sensing chamber by holding the temperature and pressure of the chamber at a constant value and exhausting the region downstream of an orifice following the chamber to a pressure low enough to maintain sonic flow through the orifice. The use of a constant pressure in the chamber permits the indication or recording made with this instrument to be referred to any desired pressure altitude. Indications can then be expressed as a fraction of lower explosive limit at some altitude, usually at sea level. A means is provided for starting or stopping an electrically operated device at some predetermined gas concentration. This latter feature is quite useful in providing an automatic safety monitor.

BIBLIOGRAPHY

Glendinning, RAE Technical Note 1075.

Horan, J. J., Onderdonk, J. R., and Witkin, E., *Reduction of Gun-Gas Explosion Hazard in Combat Aircraft*, Aeronautical Engineering Review, Vol. 11, No. 3, pp. 37–43, March, 1952.

Fenn, Industrial and Engineering Chemistry, Vol. 43, December, 1951.

Coward and Jones, Bureau of Mines Bulletin 503, 1952.

Colledge, British Ministry of Supply, Boscombe Down, Report No. AAEE/ARM/Res/40.

Maxted, E. B., *The Poisoning of Metallic Catalyst, Advances in Catalysis and Related Subjects*, Vol. III; Academic Press, Inc., New York, 1951.

Mullins, B. P., *Spontaneous Ignition of Liquid Fuels;* Butterworths Scientific Publications, London, 1955.

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A New Look at Aircraft Design Criteria *(Continued from page 57)*

ORGANIZATION REQUIRED

We have discussed what needs to be done and how it can be done. The next question is, "Who does it?"

In current practice many of the desired functions are performed by members of engineering management prior to the start of actual design work. However, these men have many other responsibilities which effectively prevent them from providing the continuity and *centralized* source of basic information so necessary to a coherent design. It therefore seems desirable that one or more experienced engineers be assigned full time to the problem of generating operational philosophy and design criteria. These men must have a broad understanding of the myriad considerations involved in the design of modern aircraft. They must be informed of a proposed project at its very beginning and allowed sufficient time to generate a workable operational philosophy and design criteria prior to extensive analysis and design by specialized groups. Furthermore they must be provided with communication channels that will allow them to keep up to date on the thinking of the customer and of top management, as well as on the results of the actual design study.

The organizational setup used will depend on the organization of the particular engineering department. The philosophy outlined above can be incorporated into an existing organization either as a staff unit, a project engineering group, or perhaps as a line unit. In any case, however, *adequate communication* must be provided along *both* project and management structure lines.

CONCLUSION

In summary the following conclusions have been reached.

(1) Criteria are continually changing.

(2) Government specifications should become more general, eliminating the need for costly formal deviations. Aircraft design practice has outgrown the state where succeeding aircraft could be designed to the same set of criteria.

(3) There should be a change in our approach to the problem of defining and utilizing design criteria.

(4) The *Structural Design Criteria* is no longer quite the comprehensive document it once was. There are other criteria that should be written covering the other aspects of the total weapon system.

(5) All criteria should be incorporated into a total unified design criteria.

(6) The design criteria must be based on a well-defined Operational Philosophy.

(7) The Operational Philosophy and the Design Criteria should be reasonably well developed prior to extensive specialized analysis or design.

(8) A special group of experienced engineers should be assigned to the problem of generating and monitoring the Operational Philosophy and Design Criteria.

(9) The special group should be fully informed from the very beginning of a project and should continue to have full cognizance of customer, top management, and design group thinking.

(10) A variety of organizational arrangements are practical *as long as adequate lines of communication both vertically and laterally are maintained.*

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Robert H. Korkegi*
University of Southern California

An Aerodynamic Means of Static-Pressure Compensation for Transonic and Supersonic Aircraft†

A technique for compensating aerodynamically for the so-called "error" in static-pressure measurement—the deviation of the measured static pressure at some location on the aircraft from the true free-stream pressure, due to the field of flow about the aircraft—from transonic and supersonic aircraft.

Symbols

M	= free-stream Mach Number
M'	= indicated Mach Number or effective free-stream Mach Number for compensator
p	= free-stream pressure
p'	= indicated pressure or effective free-stream pressure for compensator
p''	= local pressure on compensator
p_s	= stagnation pressure
q_c	= $p_s - p$ = true impact pressure
q_c'	= $p_s - p'$ = indicated impact pressure
$\Delta p/q_c$	= $(p' - p)/q_c$ = pressure coefficient of source on aircraft or static-pressure error
$(\Delta p/q_c)b$	= $(p'' - p')/q_c'$ = pressure coefficient of compensator source
$(\Delta p/q_c)r$	= $(p'' - p)/q_c$ = resultant error with compensation
c_p	= pressure coefficient as used in Fig. 1.

Introduction

The principal means of determining air speed, Mach Number, and altitude of an aircraft is from measurements of free-stream and stagnation pressure. The stagnation pressure is relatively easy to measure provided that the sensor is located outside of boundary layers and wakes on the aircraft and that, for supersonic flight, account is taken of all shock waves upstream of the sensor. However, measurement of the true free-stream pressure presents a more serious problem which is magnified by the extension of the speed range of present-day aircraft into the transonic and supersonic regimes.

The sensor, whether in the form of static orifices on the fuselage or on a boom mounted on the nose, wing, vertical tail, etc., is in a flow disturbed by the presence of the aircraft, and thus it will not generally sense the true free-stream pressure. For purely subsonic speeds it is usually possible, by careful pressure-distribution measurements, to select a location on the surface of the fuselage where the pressure has close to free-stream value over the whole speed range ("null" pressure). This is because of the fact that, for slender bodies at subsonic speeds, the surface-pressure distributions for different Mach Numbers are essentially similar and, therefore, the null pressure points are almost independent of Mach Number. However, at high subsonic speeds past the critical Mach Number, the flow field changes in character owing to local regions of supersonic flow, and the null pressure point gradually moves downstream on the body. Thus, fuselage pressure orifices which yield a good measurement of free-stream pressure at subsonic speeds will have large errors at transonic and supersonic speeds. Booms equipped with conventional pitot-static tubes are not in themselves a solution to the problem since, in order to yield a measurement of free-stream pressure within reasonable accuracy, their lengths would be prohibitive. For instance, for a typical pointed-nose body representative of transonic and supersonic fuselage shapes, the peak error at a distance of $1\frac{1}{2}$ maximum body diameters ahead of the nose may be of the order of 5 per cent of the free-stream pressure. Taking 6 ft. as a representative maximum effective

* Formerly, Research Associate, Engineering Center.

† The work described herein is part of an investigation of free-stream and stagnation-pressure measurement from transonic and supersonic aircraft sponsored by the Instruments Branch of the Flight Control Laboratory, Wright Air Development Center, under contract AF 33 (616)-2396. The assistance of the NACA in making available the 2-ft. by 2-ft. transonic wind tunnel of the Ames Aeronautical Laboratory and the cooperation of the personnel of this facility are gratefully acknowledged.

The author wishes to express his appreciation to Dr. C. L. Dailey for suggestions which led to the development of the technique of aerodynamic compensation and to his coworkers, Prof. R. L. Mannes and J. William Stuart, Jr.

A translation of a German report[4] received after the writing of this paper indicates that the idea of selecting the shape of a static-pressure source to offer compensation for the position error had been considered in Germany several years ago. From the limited information available, indications are that the primary aim was to compensate in the subsonic speed range, although one probe investigated yielded small resultant errors up to $M = 0.98$. There is no information regarding the location of the pressure source or the magnitude of the position error to be compensated. The work described in the present paper and that discussed in reference 4 were done independently.

diameter of the fuselage of a fighter aircraft, this means a 5 per cent error on a nose boom 9 ft. long. In order to maintain the error at 1 or 2 per cent, it would be necessary to have boom lengths of the order of 20 ft. which, of course, are highly impractical for service aircraft from all standpoints—weight, vibrations, ground handling, instrumentation, etc. A more detailed discussion of the field of pressure measurement from transonic and supersonic aircraft is given in reference 2.

It is apparent that a single source on a transonic or supersonic aircraft will give substantial errors in free-stream pressure determination over the whole Mach Number range. In principle, several sources could be used, each located at a null pressure point for a given Mach Number in the speed range of the aircraft. As the aircraft accelerates or decelerates, the sources could be progressively changed by some switching device. However, this technique has obvious disadvantages.

A more promising method is that of using some form of compensation for the error in static pressure measured from a single source on an aircraft. Even though compensation is used, the source should be located in the region which is least affected by angle-of-attack variations, sideslip, and configuration changes—deflection of control surfaces, position of landing gear, etc. The compensator may take the form of an electronic computer or a mechanical or electromechanical "black box" in the aircraft, which supplies a correction determined from free-flight calibration to the sensed pressure or analog thereof. A further possibility, which is the subject of this paper, is that compensation may be effected aerodynamically.

Principle of Aerodynamic Compensation

The principle of aerodynamic static-pressure compensation is quite simple. It is based on the premise that it is possible to produce a desired pressure variation with Mach Number (within certain restrictions as to pressure level and shape of the curve) by proper choice of an aerodynamic body shape and selection of the location of the pressure source on this body. For instance, if the pressure coefficient at some axial position (say Station X) on a given body ("a") is positive and increases with increasing subsonic Mach Number, as illustrated in Fig. 1(a), then it should be possible to find another body shape ("b") whose pressure coefficient at some point on its surface has approximately the inverse value of that of body "a" over the Mach Number range of interest* [Fig. 1(b)] so that, if a small-scale model of body "b" replaces a plain static-pressure probe at the selected location on body "a," it will give approximately the free-stream pressure [Fig. 1(c)]. It is, of course, assumed that body "b" is sufficiently small compared with body "a" so that it does not measurably influence the flow field of the latter.

Thus, body "b" can be considered an aerodynamic static pressure compensator for body "a" which, in turn, can be considered the fuselage of an aircraft.

Suppose the pressure coefficient, or static-pressure error, for a given location on an aircraft is $\Delta p/q_c$† and suppose the pressure coefficient for the compensator is $(\Delta p/q_c)_b$; then, the resultant error, with the compensator replacing a static-pressure sensor at this location, is

$$\begin{aligned}(\Delta p/q_c)_r &= (p'' - p)/(p_s - p) \\ &= [(p'' - p')/(p_s - p')]\{1 - [(p' - p) \div (p_s - p)]\} + [(p' - p)/(p_s - p)]\end{aligned}$$

or

$$(\Delta p/q_c)_r = (\Delta p/q_c)_b[1 - (\Delta p/q_c)] + (\Delta p/q_c) \quad (1)$$

For example, if the static-pressure error for a given source on an aircraft at $M = 0.95$ is $\Delta p/q_c = +0.10$, corresponding to which $M' = 0.88$, and if, for this M' as free-stream Mach Number, the pressure coefficient of the compensator source is $(\Delta p/q_c)_b = -0.12$, then the resultant error with compensation is $(\Delta p/q_c)_r = -0.008$ or approximately -0.01.

Ideally, one desires total compensation—i.e., an exact measure of the free-stream pressure. This requires that $p'' = p$ or $(\Delta p/q_c)_r = 0$. From Eq. (1), the compensator pressure coefficient for this case would have to be

$$(\Delta p/q_c)_{b_0} = -(\Delta p/q_c)/[1 - (\Delta p/q_c)] \quad (2)$$

In practice, one would seek a compensating body shape whose pressure coefficient at some position on its surface would be as close as possible to $(\Delta p/q_c)_{b_0}$ versus M' over the desired Mach Number range. The resultant error with this body replacing a static-pressure sensor can then be calculated from Eq. (1).

It will be noted that the same value of stagnation pressure has been used for the compensator as for the aircraft.‡ This means that at supersonic speeds the value of stagnation pressure must be the local value at the sensor location to account for losses through shock waves upstream of this point.

Example of Application

Since a single static-pressure source on a transonic or supersonic aircraft will generally result in substantial deviations from the true free-stream pressure, some form of compensation is required, and, therefore, the principle of aerodynamic compensation can be applied. In surveying the possible locations for a static-pressure source on transonic and supersonic aircraft, it appears that location on a boom ahead of the nose of the fuselage presents great advantages over other locations.[2] (There are, of course, certain disadvantages, such as interference with nose radar, ground handling problems, etc.) Such a source is far upstream of control surfaces and moving parts of the aircraft so that their influence on

* The free-stream Mach Number for body "b," corresponding to M for body "a," is the local value of Mach Number M' at Station X on body "a."

† Pressure coefficients are based on the impact pressure q_c for consistency with usage in the field of pressure measurement from aircraft.

‡ It is justifiably assumed that the error in stagnation-pressure measurement from aircraft is negligible.

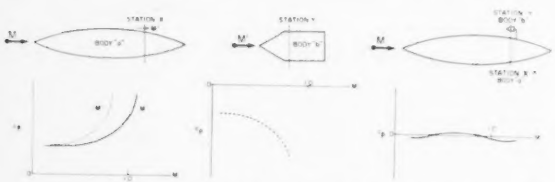
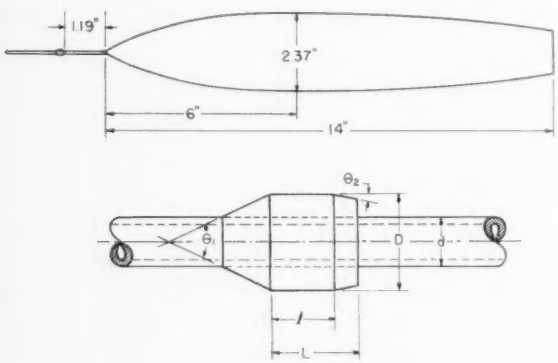


FIG. 1. Illustration of aerodynamic compensation. *Left:* (a) Station X on body "a." *Center:* (b) Station Y on body "b." *Right:* (c) Station Y on body "b" in combination with body "a."



D	d	L/D	l/L	θ_1	θ_2
1/8"	1/16"	0.75	0.67	60°	10°

FIG. 2. Sketch of body "B" and compensator. *Top:* (a) Body "B." *Bottom:* (b) Compensator.

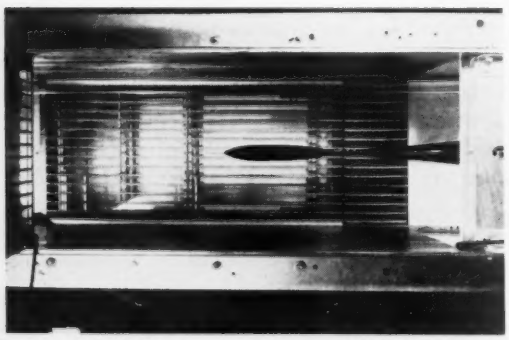


FIG. 3. Model in 2-ft. by 2-ft. transonic wind tunnel of the NACA Ames Aeronautical Laboratory. (Courtesy NACA Ames Aeronautical Laboratory.)

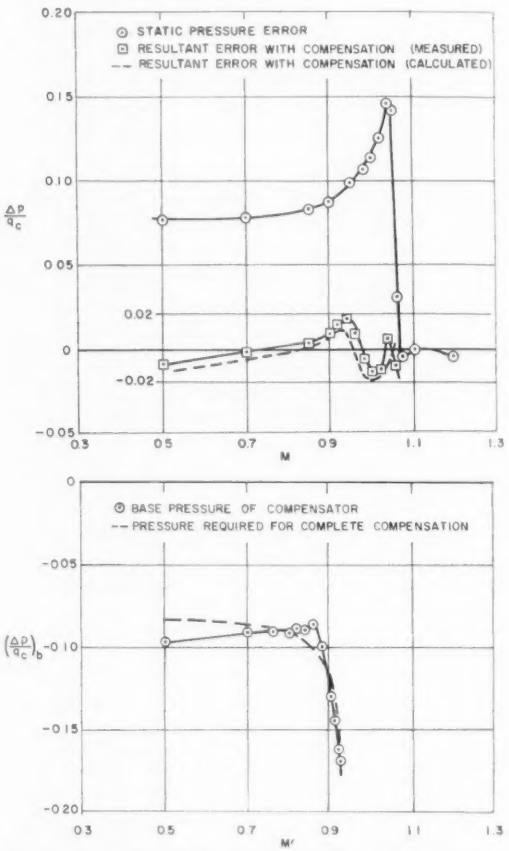


FIG. 4. Experimental check of aerodynamic compensation on body "B."[1] *Top:* (a) Pressure error with and without aerodynamic compensation. *Bottom:* (b) Base pressure.

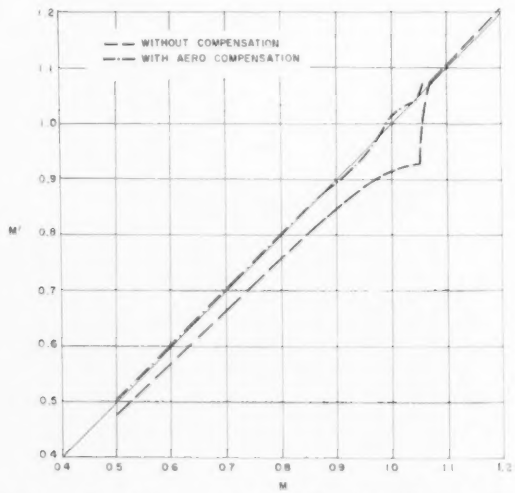


FIG. 5. Indicated versus true Mach Number with and without aerodynamic compensation.

the pressure at this point is small. In addition, such a source has the distinct advantage of being unaffected by the flow field of the aircraft at supersonic speeds once the fuselage bow shock has moved downstream from it. This may occur at a Mach Number as low as 1.01 or 1.05 ("break-off" Mach Number), depending upon the length of the boom and the shape of the fuselage. Hence, beyond this Mach Number there would be no error due to the pressure field of the aircraft. This circumstance is indeed fortunate since pressure extremes become progressively larger with increasing Mach Number, and, therefore, the static-pressure error can also be expected to have larger peak values. Hence, for a nose-boom pressure source, compensation is only required up to the break-off Mach Number. Beyond this value a plain static-pressure probe will yield the true free-stream pressure directly.

The static-pressure error, $\Delta p/q_c$, for a nose-boom source is positive and nearly constant at subsonic speeds and rises in the transonic speed range in a similar fashion to the c_p curve shown in Fig. 1(a). Therefore, the compensating source must exhibit a negative pressure coefficient which rises in absolute value in the transonic range [cf. Fig. 1(b)]. The base pressures of cones, cone-cylinders, and cone-cylinders with moderate boat-tailing were found to give the desired variation with Mach Number.[2,3]

The model selected for an experimental check of aerodynamic compensation is a body of revolution (body "B" of reference 1) whose nose shape is similar to that of the X-1 airplane without the cockpit and nose-gear enclosures. The ordinates of body "B" were supplied by the Langley Aeronautical Laboratory of the NACA. The nose shape is representative of that of present transonic and supersonic aircraft but has a comparatively large nose angle so that the static-pressure error is also comparatively larger.

A compensator shape was experimentally obtained for a position one half maximum diameter ahead of the nose of body "B."* The data used for this purpose were static-pressure error results obtained at the NACA Langley Laboratory by the wing-flow method.[1] Body "B" and its aerodynamic compensator—a cone-cylinder with slight boat-tailing—are shown in Figs. 2(a) and 2(b), respectively. The sting supporting the compensator extended forward of the compensator so as to simulate a plain pitot-static probe which would serve as a free-stream pressure source beyond the break-off Mach Number.

Experimental Results

The tests were made in the 2-ft. by 2-ft. transonic wind tunnel of the NACA Ames Laboratory. A photograph of the model in the tunnel is shown in Fig. 3. For the tests presently reported, the reservoir pressure was maintained at 15 psia over a Mach Number range of from 0.50 to 1.20. The Reynolds Number at the base of the compensator (based on the distance from the nose of the sting) varied from approximately 1/2 to 3/4 $\times$ 10^6 over this range. Variation of reservoir pressure indicated slight sensitivity of the base pressure to *Re*. For this anticipated reason, the tunnel conditions at Ames were maintained essentially the same as those in the U.S.C. Engineering Center facility. However, for a full-scale flight installation, it is anticipated that the Reynolds Number would always be sufficiently high so that the effect of this parameter would be within the allowable error in pressure determination.

Measurements of the static-pressure error one half diameter in front of the nose of body "B" are shown in coefficient form in Fig. 4(a). These vary from approximately $\Delta p/q_c = 0.08$ to a peak of 0.15 before the bow wave crosses this position between $M = 1.05$ and 1.07. Beyond $M = 1.07$ the pressure has essentially the free-stream value.

The base-pressure variation with Mach Number (the indicated Mach Number for body "B") for the compensator alone is shown in Fig. 4(b). The large drop in base pressure beyond $M' = 0.85$ is caused by supersonic expansion of the flow separating from the base when the shock wave terminating the local region of supersonic flow has moved downstream of the compensator. The dashed curve in this Figure, calculated from Eq. (2), represents the compensator pressure required for complete compensation.

The resultant error with the compensator on the nose boom of body "B" is shown in Fig. 4(a). Its peak value is less than $(\Delta p/q_c)_r = 0.02$, or approximately 10 per cent of the uncompensated error. Also shown in Fig. 4(a) is the resultant error, calculated from the static-pressure error and the base-pressure coefficient by means of Eq. (1). It can be seen that the calculated value is quite adequate for practical purposes.

In Fig. 5 is shown the indicated Mach Number versus true Mach Number as obtained from static- and stagnation-pressure measurement with and without aerodynamic compensation. Without compensation, the maximum error in Mach Number determination is $\Delta M = 0.12$. With aerodynamic compensation it is reduced to $\Delta M = 0.015$.

The base-pressure error and, to a lesser extent, the static-pressure error ahead of the nose of the body are sensitive to large angles of attack. However, the purpose of this paper is to indicate the feasibility of compensating aerodynamically, and it is felt that insensitivity of the compensator pressure to angle of attack, or even some degree of compensation for the change in pressure due to angle of attack, could be obtained by circumferential selection of the compensator orifice location—as done for plain static-pressure probes. This may require an orifice location on the surface of a compensating body rather than in the base since the surface-pressure extremes with angle of attack around the circumference of the body provide a wider range than exists around the base.

* Credit for experimentally determining the compensator geometry is due J. William Stuart, Jr. These tests were made in a 4.5- by 5-in. slotted transonic working section at the University of Southern California Engineering Center.

Thus, the axial position of the orifice on the compensator is selected to compensate for the static-pressure error at zero angle of attack, and the circumferential position is selected to compensate for the change in the error with angle of attack.

Conclusions and Discussion

Compensation for the error in static-pressure measurement from transonic and supersonic aircraft can be successfully accomplished by means of an aerodynamic body as pressure sensor in lieu of a plain static-pressure probe. The shape of the aerodynamic body and the location of its pressure orifice are selected to provide a pressure variation with Mach Number essentially opposite to that due to the field of flow about the aircraft at the sensor location.

By this technique, it is experimentally shown that the error in static-pressure measurement from a nose-boom installation can be reduced by a factor of approximately ten, and the maximum error in Mach Number determination is reduced from $\Delta M = 0.12$ to $\Delta M = 0.015$. Although the selected compensator source and the static-pressure error are sensitive to large angles of attack, it is felt that some compensation in this direction can be effected by selection of the best circumferential location for the orifice on the compensator body surface.

For a nose-boom installation, compensation is only required up to the break-off Mach Number. Beyond this speed a plain static-pressure probe will give the true free-stream pressure. Thus, a nose-boom installation would consist of two pressure sources—an aerodynamic compensator and a plain static-pressure probe. The two would be concentric, with the static-pressure probe mounted in front of the compensating body. A switch, sensitive to static to stagnation pressure ratio, would trigger a two-way valve system at the break-off Mach Number, thus shutting off the compensator pressure line and opening the line to the static-pressure probe (or the inverse, in deceleration from supersonic to subsonic speeds).

The great advantages of an aerodynamic compensator are that (1) it can be a small, light-weight body; (2) it involves no moving parts and, therefore, has a high degree of reliability; and (3) no source of power is required (other than for the source switching device).

In case of power failure, a solenoid could switch to the compensator source, and, since the aircraft would presumably decelerate for a landing, accurate pneumatic instrument readings could still be obtained.

References

[1] Danforth, E. C. B., and Johnston, J. F., *Error in Airspeed Measurement Due to Static-Pressure Field Ahead of Sharp-Nose Bodies of Revolution at Transonic Speeds*, NACA RM L9C25, August 19, 1949.

[2] Korkegi, R. H., and Mannes, R. L., *Investigation of Free-Stream Pressure and Stagnation Pressure Measurement from Transonic and Supersonic Aircraft—Phase I—Survey and Analysis*, WADC TR 55-238, March, 1955.

[3] Mannes, R. L., and Stuart, J. Wm., *Investigation of Free-Stream Pressure and Stagnation Pressure Measurement from Transonic and Supersonic Aircraft—Phase II—Experimental*, USCEC Report 33-202 (to be published as WADC TR).

[4] Bäuerle, H., *Measuring Instruments for Pressure, Velocity and Direction Measurements*, MAP-V.G.-251, Reports and Translations, No. 951, March 14, 1947.

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25th Annual Meeting

New York
Jan. 28–31, 1957

Summary of Technical Sessions†

By Allan Bernhardt*

The 1957 Annual Meeting of the Institute was held on January 28–31 in New York City. Delegates who packed technical session meeting rooms to capacity acclaimed it an especially noteworthy milestone in the advancement of the arts and sciences of aeronautics.

The quality and breadth of vital information readily available to engineers, designers, technical specialists, and management personnel—both IAS members and nonmembers—also marked the 25th Annual Meeting as a fitting monument to the Institute's Silver Anniversary.

This information, from Aerodynamics to VTOL-STOL Aircraft, was presented in 97 technical papers, panel discussions, and special reports grouped in 25 sessions. All of it will be evaluated for possible publication in either the REVIEW *or* JOURNAL.

Six sessions were held on Monday, Tuesday, and Thursday. Seven took place on Wednesday, four running simultaneously. Other societies cooperated in 10 of the 25 sessions.

Lecturers represented not only Government and some of the most illustrious names in the aviation industry in the United States but Europe as well.

It is to these scientists and engineers and to the capable and hard-working session chairmen that the Institute is indebted for the greatest Annual Meeting in its history.

Statistically, a total of 2,567 registrations were counted—a figure greater by about 10 per cent than 1956 attendance. Summaries of what this group heard and saw at the meeting follow in alphabetical order.

Aerodynamics—I, II, & III

Thirteen papers were devoted to information in this field. Session chairmen were Theodore von Kármán, Chairman, AGARD, NATO; W. R. Sears, Director, Graduate School of Aeronautical Engineering, Cornell University; and Allen E. Puckett, Director, Operations, Weapon Systems Development Laboratories, Hughes Aircraft Company.

Delegates heard Lucien C. Malavard, Professor at the University of Paris, discuss "Recent Developments in the Method of the Rheoelectric Analogy Applied to Aerodynamics." He pointed out that rheoelectric calculation requires only simple, economical means and that its flexibility in application allows easy passage, using the same experimental materials, from one type of problem to another.

Sir Geoffrey I. Taylor, of Trinity College, Cambridge University, England, presented a paper on "Effects of Compressibility at Low Reynolds Numbers," advocating further study of an experiment by Prof. M. Reiner at the International Congress for Applied Mechanics in Brussels, Belgium, last September. He reasoned that, if Reiner's interpretation of the experiment is correct, "the Navier-Stokes equations do not describe the mechanics of airflow, and since almost all aerodynamical investigations carried out in the last 20 years are based on them, we ought to accept Reiner's challenge and either show him to be wrong or reconstruct our science almost from its foundations."

"Effects of Leading-Edge Separations on Thin Wings in Two-Dimensional Incompressible Flow" was discussed by L. F. Crabtree, of the Royal Aircraft Establishment, England. He observed that, while a "fairly complete picture of the phenomenon of laminar separation bubbles on thin airfoils at incidence is now available, a number of points, such as the viscous flow inside the bubble, require further investigation." The study of three-dimensional separations was recommended.

A paper by Jean Fabri and Raymond Siestrunck, of France's ONERA, on "Rotating Stall in Axial Flow Compressors," discussed the aerodynamic theory of rotating stall, concluding that it necessitated very few assumptions on the behavior of the stalled blade channels. While the predictions of some properties of the rotating stall were said to be well verified by experimental measures, the authors stated that the theory is unable to predict, without preliminary experiments, the exact point of onset of the rotating stall, the number of stall zones and the change of one stall configuration to another, or the influence of blade solidity on stall propagation when the blades are not close enough together.

Jacques Valensi, Director, Institut de Mécanique des Fluides de l'Université d'Aix-Marseille, France, reported on the application of stagnation-pressure measurements and smoke surveys in the investigation of rotating stall on a single-stage axial flow compressor. His paper was entitled "Experimental Investigation of the Rotating Stall in a Single-Stage Axial Compressor." Results which were in good agreement were claimed for the two techniques.

In a paper entitled "An Aerodynamic Screen for

† Available Preprints of Annual Meeting papers are listed on p. 176.

* Assistant Editor, REVIEW.

Jet Engines," Harold Klein, Design Specialist, Aerodynamics, for the Santa Monica Division of Douglas Aircraft Company, Inc., delved into the problem of jet engines picking up material from runways and recited experiments which resulted in development of the Blowaway Jet device being patented by Douglas. The principle is a small jet of air directed toward the ground from below each engine of a jet aircraft. The small jet carries to the ground, inducing velocities sufficient to convect away the stagnation point of the vortex and to prevent any vortex from attaching below the engine inlet. It was found that the Blowaway Jet represented a simple, safe, economical scheme for effecting a very large reduction in the amount of engine damage to be expected from material pickup on runways.

John G. Lowry, John M. Riebe, and John P. Campbell, of Langley Aeronautical Laboratory, NACA, concluded in a review of "The Jet-Augmented Flap" that "it is evident that the device is capable of developing very large lift coefficients and giving thrust recoveries larger than the jet reaction in the thrust direction." The authors pointed out that, although there are problems associated with stability and control of the jet-augmented-flap airplane, "it has been shown that they can be solved to allow flight at very low speed." They asserted, also, that many other problems, besides aerodynamic, have to be considered.

Mr. Lowry is Head, 300-m.p.h. 7- by 10-Ft. Tunnel Section, Mr. Riebe is Supervisory Research Engineer, and Mr. Campbell is Head, Free-Flight Tunnel Section.

Charles H. Murphy, Jr., in a paper on "The Prediction of Nonlinear Pitching and Yawing Motion of Symmetric Missiles," reported on an approximate solution of the nonlinear angular motion of a symmetric missile. The author, who is Deputy Chief, Free Flight Aerodynamics Branch of the Ballistic Research Laboratories at Aberdeen Proving Ground, also introduced the concept of an amplitude plane which is associated with the solution. The concept was shown to be very valuable in the determination of the dependence of the type of motion on initial conditions.

A paper by Alvin H. Sacks, Aeronautical Research Engineer at Ames Aeronautical Laboratory, NACA, entitled "Vortex Interference Effects on the Aerodynamics of Slender Airplanes and Missiles," was concerned with the calculation of the vortex strengths and positions at the tail and, particularly, of the corresponding forces and moments due to vortex interference. Results of a water-tank experiment were presented to show the influence of the tail on the positions of the vortices shed by the wing.

Antonio Ferri, Joseph J. Clarke, and Lu Ting, of the Polytechnic Institute of Brooklyn, were coauthors of a paper on "Favorable Interference in Lifting Systems in Supersonic Flow." The presentation concluded that "it appears that slender bodies and pylons can be located under wings with small, or even negative drag rise. Antisymmetric modifications of the fuselage near the mid-wing can provide significant drag reductions in lifting wing-body combinations."

Some of the effects of the existence of finite relaxation times for the inert degrees of freedom of oxygen and nitrogen molecules on aerodynamic flow phenomena in the hypersonic regime were discussed in the paper, "Relaxation Phenomena in Hypersonic Aerodynamics," by J. G. Logan, Jr., Head, Theoretical Flow Physics Section, Cornell Aeronautical Laboratory, Inc. Recent experimental investigations were cited which indicate a much earlier onset of dissociation for oxygen molecules than was previously indicated by theoretical considerations.

Two methods for the calculation of flow fields in the region between a blunt body and its accompanying shock for very high-speed flow were presented in the paper, "Inviscid Hypersonic Flow Past Blunt Bodies," by Stephen H. Maslen and W. E. Moeckel, of NACA's Lewis Flight Propulsion Laboratory. Calculation effort in each case was described as moderate even when real gas effects were admitted. Mr. Maslen is Aeronautical Research Engineer; Mr. Moeckel, Assistant Chief, Supersonic Propulsion Division.

A paper on "The Magnus Force on Spinning Cylinders," by Ray W. Van Aken, Head, Fluid Dynamics Section, Aerodynamics Branch, and Howard R. Kelly, Head, Aerodynamics Branch, U.S. Naval Ordnance Test Station, listed results of recent experiments conducted in the University of Notre Dame smoke tunnel and the Convair subsonic wind tunnel on spinning cylinders. It was shown that at low spin rates the Magnus force may be positive or negative, depending on the Reynolds number—this variation corroborating data obtained by Lafay and Betz.

Aeroelasticity—I & II

A total of nine sessions in this highly important and growing field of interest were led by Martin Goland, Vice-President, Southwest Research Institute, and Robert Rosenbaum, Chief, Dynamics and Loads Group, Civil Aeronautics Administration. The first paper in Mr. Goland's session was "On the Simulation of Random Excitations for Airplane Response Investigations on Analog Computers."

The authors, Bernard Mazelsky and Harry B. Amey, Jr., Flight Dynamics Research Group Engineer and Dynamicist A, respectively, at Lockheed Aircraft Corporation, presented a method of electrical simulation permitting evaluation of a wide class of aircraft dynamic problems involving random excitations, the bulk of which cannot be treated conveniently by current mathematical techniques.

A presentation by Albert S. Richardson, Jr., Executive Officer, Aeroelastic and Structures Research Laboratory of Massachusetts Institute of Technology, and President and Technical Director, Research Consulting Associates, discussed "Nonlinear Oscillations of an All-Movable Stabilizer at Supersonic Speeds." An all-movable stabilizer, with the hydraulic servomechanism, was studied analytically as a three degree of freedom dynamic system. Five types of unstable behavior were listed. Primary emphasis was placed on closed-loop behavior near the classical flutter

instability. A linear analysis was followed by a nonlinear analysis.

The problem of panel flutter of rectangular simply supported plates subjected to supersonic flow over one surface was treated theoretically in the paper, "Flutter of Rectangular Simply Supported Panels at High Supersonic Speeds," by John M. Hedgepeth, Head, Dynamics and Aeroelasticity Section, NACA Langley Aeronautical Laboratory. The assumption was verified that the "static" approximation to the aerodynamic flutter forces yields flutter boundaries with satisfactory accuracy for Mach Numbers greater than about 2.

A paper on "The Encounter of an Airfoil with a Moving Gust Field," was presented by Norman P. Hobbs. The transient downwash resulting when an airfoil enters a moving gust field at an arbitrary rate (not necessarily at the forward speed of the airfoil) was considered for incompressible, nonviscous flow. Mr. Hobbs is Vice-President and Technical Director, AviDyne Research, Inc., and Senior Engineer in the Aeroelastic and Structures Research Laboratory at M.I.T.

The final paper in the first Aeroelasticity Session was "Unsteady-Lift Functions for Penetration of Traveling Gusts and Oblique Blast Waves," by F. W. Diederich, Head, Dynamic Loads Analysis Section, and J. A. Drischler, Jr., Aeronautical Research Engineer, both of NACA Langley Aeronautical Laboratory. The results of some calculations of the unsteady lift due to the penetration of sharp-edged traveling gusts were presented. Their use in such calculations as that of the lift due to the penetration by a given wing of an oblique blast wave or of the downwash field of another wing was discussed briefly.

The first paper in the Aeroelasticity—II Session was "Flutter Model Testing at Transonic Speeds," by W. P. Targoff, Assistant Head, Aero-Mechanics Department, and R. P. White, Jr., Head, Aeroelastic Research Section, Aero-Mechanics Department, of Cornell Aeronautical Laboratory, Inc. Construction of acceptable models and their use in the C.A.L. 3- by 4-ft. transonic test facility were described.

"The Effects of Flexibility on the Longitudinal Dynamic Response of the B-47 Airplane" was discussed in a paper by H. A. Cole, Jr., and S. C. Brown, Aeronautical Research Engineers of Ames Aeronautical Laboratory, NACA, and E. C. Holleman, Aeronautical Research Engineer, High-Speed Flight Station, NACA. The frequency response of the B-47 to elevator control was presented for ranges of frequencies including the airplane oscillatory short-period mode, the wing first-bending mode, and the fuselage first-bending mode. Comparisons were made between responses measured in flight and those predicted by pseudostatic analysis and by dynamical analysis.

Edward Widmayer, Jr., Dynamics Engineer, The Glenn L. Martin Company, presented a paper on "Structural and Impact Loads for the Flexible Airplane During Water Landings." Based on results of a research program to study loads developed during impact of water landings, the paper developed a theory for calculating structural loads caused by landing impact over a wide range of landing conditions, gave a brief review of an experimental program, and listed a correlation and comparison of experimental and theoretical loads imposed in landings on smooth seas.

The basic mechanism of flutter was outlined briefly, and factors leading to increased importance of flutter in design of high-speed airplanes were reviewed in the paper "The Application of Rocket Sled Techniques to Flutter Testing." Authors were W. R. Laidlaw, Chief, Dynamic Science, and V. L. Beals, Jr., Group Leader, Flutter and Vibration, North American Aviation, Inc.

Airspace Utilization for Air Traffic Control and National Defense

(In Cooperation with the Institute of Radio Engineers and Radio Technical Commission for Aeronautics)

Chairman of this session, consisting of three papers, was James Anast, Systems Planning Advisor to the Special Assistant to the President for Aviation Facilities Planning. The lead paper was a discussion of "Airspace Use for Air Traffic Control and Air Defense," by D. D. Thomas, Director, Office of Air Traffic Control, Civil Aeronautics Administration. Mr. Thomas listed trends in airspace use growth and discussed some of the thinking within the CAA. On the current airspace situation, he pointed out: "We have reached a point of saturation to the degree that we can no longer allocate airspace for the exclusive use of any one activity, and we must keep in mind the necessity of the concurrent joint use of airspace."

D. R. Israel and Herbert Sherman, Staff Members, Lincoln Laboratory, M.I.T., declared in a paper on "Common or Uncommon Systems: Air Traffic Control and Air Defense" that intelligent planning depends on complete specification of the needs and requirements for air traffic control. They also said that the future will demand a semiautomatic traffic control system but added that information currently available will not permit the firm statement that a common ground control facility will be feasible. Regarding common use of radar, beacon, and ground-air communication facilities, the authors asserted that it is technically feasible, economically desirable, and operationally important at the present time.

In a discussion of "Air Force Air Traffic Control," Col. S. A. Mundell, Deputy Chief, Electronic Supporting Systems Project Office, Headquarters, ARDC, declared that from a USAF view, the system for control of air traffic during war must be identical to that used in peacetime. He added that, because of expected wartime expansion and present overseas commitments, the traffic controlling organization must be a joint one.

Education

(In Cooperation with the American Society for Engineering Education, Aeronautical Division)

Chairman of this illuminating session, which presented a remarkable insight into the relationship

between learning and the engineer and his role in the continued air leadership of the United States, was John W. Hoover, Associate Professor at the College of Engineering, University of Florida.

The opening paper in this session fired the warning that loss of leadership in technology by the United States "would be a serious blow to the free world militarily, economically, and politically." The speaker was Col. Edward H. Wynn, Directorate of Development Planning, Headquarters, USAF. His paper, "The Challenge to America's Leadership in Technology," took the position that success in retaining this leadership can be achieved by immediate long-range and short-range action in the field of education and research.

John F. Victory, Executive Secretary of the NACA, in a paper entitled "The Engineer Shortage," disclosed that the NACA is facing a critical situation with respect to retention of top scientists because of the Government's rigid pay structure—in contrast to the rising market price for labor in industry. The author called for a flexible pay scale in Government to keep it in competition for skills with industry.

In a paper entitled "Help Wanted," R. W. Middlewood, Chief Engineer, Georgia Division, Lockheed Aircraft Corporation, reviewed the need for engineers in the aircraft industry and discussed some reasons why he thinks a shortage exists. The author also listed his suggestions as to what the industry can do to help itself toward alleviation of the engineer dearth.

The "Problems of Raiding University Faculties by Industry" were discussed by John D. Akerman, Professor at the University of Minnesota. The raiding practice, he declared, is one which can undermine the process which gives the nation its supply of aeronautical engineers. In contrast, he pointed to the cooperation of industry in supplying teachers on a part-time basis and/or providing consulting fees to outstanding faculty members, thus increasing their income and decreasing any desire they may have to leave the teaching profession.

Electronics

(In Cooperation with the Institute of Radio Engineers and Radio Technical Commission for Aeronautics)

This session, providing several manuscripts which will appear in the annual Electronics in Aviation issue of the REVIEW next month, was headed by David S. Little, Superintendent of Airways Aids and Electronics, American Airlines, Inc.

A plea for support to early establishment of technical standards—"so we may enter the jet transport age with assurance of steady progress forward in the important matter of air traffic control if nothing else"—was made in the paper, "Common System Standards," by H. K. Morgan, Director of Commercial Aviation Systems, Bendix Aviation Corporation.

Vernon I. Weihe, Staff Consultant, Air Navigation and Traffic Control, Air Transport Association of America, delivered a paper on "Air-Borne Computers Will Reduce Cockpit Load." The author recommended that a system characteristic for transport category aircraft be prepared after outlining the application of central air-borne digital computers to civil transport operations for several regimes of flight.

"Component Developments Influencing Aviation Electronics" was the title of a paper by Luther Davis, Jr., Research Staff Member, and L. G. Rubin, Assistant Research Staff Member, Raytheon Manufacturing Company. The status of present and future electronic components featuring reliability, small size and weight, low power consumption, and operation at elevated temperatures was discussed.

Problems of concern to aircraft, electronic, and materials engineers "who must start working cooperatively very early in the design of any new system requiring air-borne antennas" were outlined in the paper, "Antenna System Problems with High-Speed Aircraft," by F. W. Bushman, Chief, Antennas and Electronic Equipment Unit, Physical Research Staff, Boeing Airplane Company.

Engineering Management

(A Symposium)

This presentation, consisting of four papers, was presided over by E. A. Ledeen, Engineering Administrator, Wright Aeronautical Division, Curtiss-Wright Corporation. The titles of the papers and their authors follow:

"The Symbiosis of Universities and Industry," by A. A. Fejer, Chairman, Department of Aeronautical and Mechanical Engineering, The University of Toledo.

"The Consulting Psychologist and Engineering Management," by T. T. McKnelly, Consulting Psychologist, Rohrer, Hibler & Replogle.

"Management for Product Development," by R. C. Sebold, Vice-President—Engineering, Convair.

"The Purpose of Engineering Management," by E. C. Wells, Vice-President—Engineering, Boeing Airplane Company.

Mr. Fejer urged industry to include as part of its regular operating expenditures "contributions to our institutions of higher learning, with no strings attached, to be spent by the schools for the support of scientific inquiry and for the education of future generations of scientists. Mere coexistence," he said, "will not suffice."

Mr. McKnelly told his audience that a "company or technical organization is no stronger than its people," and, if it wants to keep in a growing condition and be competitive with strength, it must place strong emphasis on helping its people to improve themselves. He added, "Now if the management of a company accepts this axiom, then it becomes easy to understand the why of retaining psychological counsel. The purpose is simply to provide an additional tool for helping people grow and improve themselves."

Mr. Sebold described the tools of management as people, development facilities, and manufacturing

(Continued on page 74)

LIFELINE

••• --- ••• These are the "call letters" of the U. S. Coast Guard. Watching over more than half a million square miles of our coastal waters, the rescue record of this famous organization is one of the great air-sea sagas of war and peacetime service. Helping to extend the Coast Guard's far-flung lifeline is the Martin P5M and the new P5M-2G, providing long-range sea reconnaissance for any emergency. Also, in active service with both the Atlantic and Pacific fleets of the U. S. Navy, ten squadrons of this famous seaplane—specially armored for anti-submarine warfare—are in operation today, from Norfolk to the Mediterranean and from Washington to the Orient.

MARTIN

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Summary of Technical Sessions (Continued from page 72)

capability. He said that they are the same, the difference being in how they are used. In answer to his question, "How do we use them differently?," he said, "I think we do it by better planning, technical planning, management planning, facility planning, manufacturing planning, to the end that we have the right kind of skills and facilities when we need them."

Mr. Wells proposed the idea that "an engineering organization must eventually produce useful ideas and products if it is to exist long enough to grow and prosper. Furthermore, I am suggesting that the proportion of our effort not directed toward ultimate useful production must be proportioned in magnitude in a reasonable relationship to invested capital and business volume both present and anticipated."

Flight Safety

(In Cooperation with The Daniel and Florence Guggenheim Aviation Safety Center at Cornell University)

Jerome Lederer, Director of the Flight Safety Foundation and of the Cornell-Guggenheim Aviation Safety Center, was chairman of this session.

Major factors contributing to injuries in survivable-type accidents in which transport planes have been involved and the design precepts which can be used to eliminate these injury causes were given in the first paper. The presentation was by A. H. Hasbrook, Director, Aviation Crash Injury Research, Cornell University, on "General Design Requirements for Crashworthiness and Delethalization of Passenger Transport Aircraft."

A long-range program for continued work in the field involving tests and developments concerning aircraft in progress at the CAA Technical Development Center in Indianapolis was proposed in the paper, "Technical Bases for Safer Aircraft," by A. L. Morse, Chief of the Center's Aircraft Division.

Captain L. H. Mouden, of Braniff Airlines, Chairman, Air Worthiness and Performance Study Committee of the Air Line Pilots Association, presented a paper on "The Air-Line Pilot's Concept of Transport Performance Requirements." The author stressed that the ALPA has specialized committees of qualified men working on various technical issues of aviation and said that the complete resources of the association are available to the aviation industry without obligation. His paper urged consideration of "more encompassing performance requirements for transport airplanes."

Flight Testing

(In Cooperation with the Society of Experimental Test Pilots)

Regrettably, automobile accident injuries sustained shortly before the meeting prevented Ray E. Tenhoff, Engineering Test Pilot for Northrop Aircraft, Inc., from presiding over this session. Robert M. De Haven, Assistant Director, Aircraft Operations and Flight Test Division, Hughes Aircraft Company, filled in, introducing the session's three papers.

The first paper, "Flight-Testing Stability Augmentation Devices for High-Performance Fighters," by A. W. Blackburn, Engineering Test Pilot, Engineering Flight Test, North American Aviation, Inc., defined augmentation devices and divided them into two categories. A general flight-test technique for ultimate proof of nearly all such stability devices was presented.

The paper, "Understanding and Interpreting Pilot Opinion," by G. E. Cooper, Chief Aeronautical Research Pilot at the NACA Ames Laboratory, was published in last month's issue of the REVIEW.

Increased expenditure of engineering effort to check the trend of decreasing percentage of successful escapes was recommended in the paper by T. G. Kilgariff, F5D Project Test Pilot, Flight Test Division, Douglas Aircraft Co. The presentation discussed "The Trend in Escape from High-Performance Aircraft."

Guided Missiles

This heavily attended session was conducted by Clark B. Millikan, Director, Guggenheim Aeronautical Laboratory, California Institute of Technology, and Chairman, Aircraft and Guided Missiles Panel, USAF, Scientific Advisory Board. Featured were full-scale addresses by Lt. Gen. James M. Gavin, Chief of Research and Development, U.S. Army; Rear Adm. J. E. Clark, USN, Director, Guided Missiles Division, Office of DCNO (Air); and Major Gen. Bernard A. Schriever, USAF, Commander, Western Development Division, ARDC.

In his "Report on Missile Development," General Gavin presented a summary, illustrated by films and slides, on missile development progress. On Department of the Army authorization, General Gavin announced the La Crosse Missile, which he described as deadly accurate for close tactical support of ground troops in the field.

In a talk on "The Status of the Navy's Guided Missile Program," Adm. Clark lauded progress made but said he thought it was time "to take stock of what we have done, measure our accomplishments and set a course for the future." The Admiral said that in one area—the actual development, testing, and production of missiles—success has been great. He expressed himself as "only partially satisfied" in a second area, however, warning that "we have got to hammer out some of these little bugs that push our reliability down." In a third area—the matter of cost—Admiral Clark said, "we have failed miserably," adding, "when we start mass producing for our operating forces, and unit costs still continue to rise instead of going down, we must take steps to find the trouble." Corrective measures recommended by the Admiral were: Think cost from the beginning of any design, strive to arrive at early component specifications, eliminate all frills possible, try to put the human back in the missile loop whenever possible, look for ways to reduce the number of parts, utilize experience of cost

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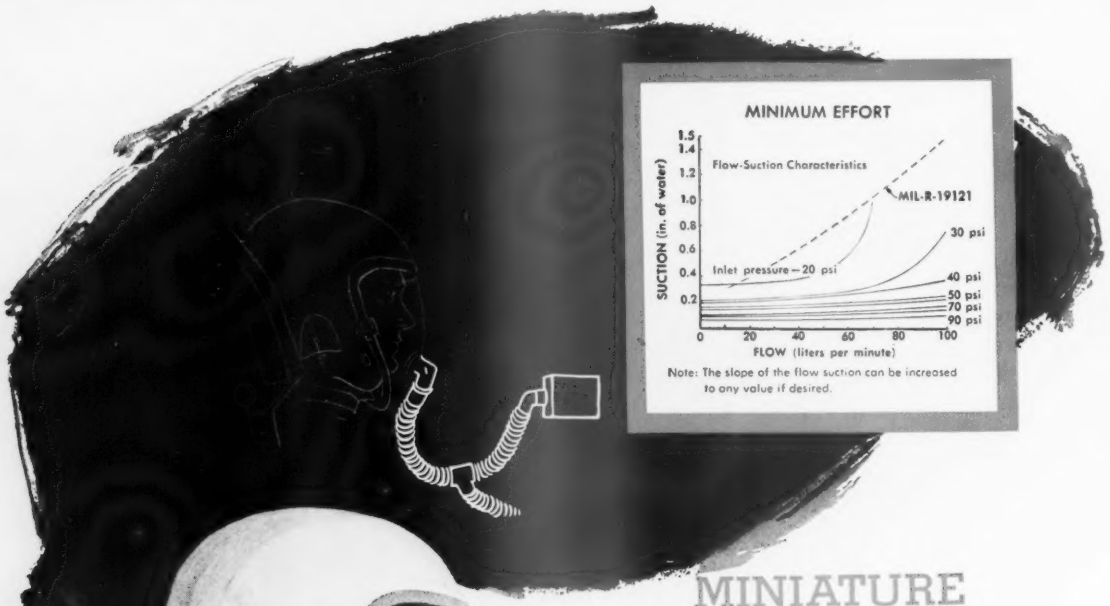

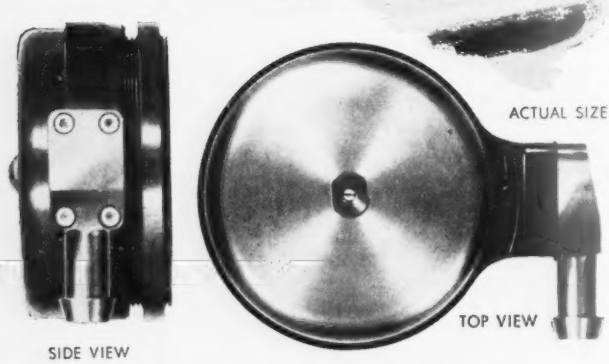

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experts, and (first remedy repeated for emphasis) think cost from the beginning.

General Schriever, who spoke on "Guided Missiles Research and Development in the U.S. Air Force," presented a comprehensive review of the missiles of the Air Force, including a study of the research and development phase of USAF effort.

Notwithstanding the importance of missiles operational or being developed by the Air Force, General Schriever said that top priority is being given to the ICBM and IRBM programs, with full authority and responsibility being delegated to the Western Development Division in Los Angeles.

Helicopter Design

(In Cooperation with the American Helicopter Society)

Chairman of this session was Ralph B. Lightfoot, Chief of Flight Research at Sikorsky Aircraft Division, United Aircraft Corporation.

A paper on "Reliability Requirements for Helicopter Flight Controls," by Herbert Hecht and Lawrence Kaufman, of the Helicopter Flight Controls Department, Sperry Gyroscope Company, stressed that the increasing use of helicopter flight-control systems makes it desirable to establish close control over the reliability of such equipment. The application of numerical techniques to a design was shown in an example. The need for accuracy in defining equipment failure was emphasized, and benefits derived from redundancy of critical components were illustrated.

The second paper was "Correlation of Helicopter Performance Equations," by I. A. Sikorsky, Chief Aerodynamicist, Sikorsky Aircraft Division, United Aircraft Corporation. It presented a correlation and unification of helicopter performance equations in forward flight and showed that calculation made by the energy method, by the balance of forces, or by combination of both methods yields identical results only if the same basic assumptions and approximations are used.

A method for rapid estimation of the flight performance of compound-type rotorcraft, making extensive use of nomograms to avoid lengthy computation, was developed in a paper by R. D. Foster, Aerodynamicist, Bell Helicopter Corporation, entitled "A Rapid Performance Prediction Method for Compound-Type Rotorcraft." The method was based on familiar helicopter theory modified to include the effect of interaction between wings and rotors.

The final paper of the session was "Developments in Cooling Systems for Helicopter Power Plants," by H. A. Wahl, Internal Aerodynamics Group Engineer, Vertol Aircraft Corporation. A brief review was given of the significance of energy expended in helicopter power-plant cooling. Several means of reducing cooling power were listed.

Helicopter Dynamics

(In Cooperation with the American Helicopter Society)

Bartram Kelley, Vice-President and Chief Engineer, Bell Helicopter Corporation, was chairman of this session. The first paper was "Differential Delta-Three: A Method for Improving the Longitudinal Stability of the Tandem Helicopter," by A. C. Adler, Principal Engineer, Cornell Aeronautical Laboratory, Inc. It presented a discussion and brief theoretical analysis of differential, the effects on the angle of attack stability, and the control problems associated with the use of this type of system.

It was the conclusion of the second paper in the session that considerable improvement in tandem helicopter characteristics should be possible without recourse to heavy or complicated stabilization provisions. The paper was "An Investigation of the Handling Qualities of Tandem Helicopters," by D. F. Gebhard and Leonard Goland of Kellett Aircraft Corporation. The authors are Chief of Preliminary Design and Director of Research, respectively.

Design features of tilt-wing-type VTOL aircraft in relation to those aeroelastic problems which are likely to be affected were discussed in the paper, "Some Aeroelastic Problems of Tilt-Wing VTOL Aircraft." The authors were R. G. Loewy, Chief Dynamics Engineer, and R. Yntema, Dynamics Engineer of Vertol Aircraft Corporation.

Results of measuring the response of models to known exciting forces applied by an electromagnetic shaker while rotating on a spin test rig were discussed in the final paper of the session, "Investigation of Helicopter Blade Flutter and Load Amplification Problems." The authors of the presentation are three engineers of Cornell Aeronautical Laboratory, Inc.: Hamilton Daughaday, Head, Helicopter Section; and G. Gates and F. DuWaldt, Research Engineers in the Aero-Mechanics Department.

IGY Earth Satellites

Joseph Kaplan, Chairman of the U.S. National Committee for the International Geophysical Year, was chairman of this session, begun with a paper on "Current Status of the U.S. Earth Satellite Program for the International Geophysical Year," by R. W. Porter, Consultant, Communication and Control, General Electric Company, and Chairman, USNC-IGY Technical Panel on the Earth Satellite Program. Mr. Porter disclosed that designs have been frozen for the satellite, its boosters, and the instrumented experiments as well as for the optical and radio tracking networks. He said procurement is about on schedule with one or two exceptions and forecasted that performance will be at least as good as planned.

J. P. Hagen, Director, Project Vanguard, Naval Research Laboratory, in delivery of a paper on "Radio Tracking Orbit and Communication for the Earth Satellite," discussed Minitrack—a radio tracking system, the chain of receiving stations extending from Washington, D.C., to Santiago, Chile, and computers which will forecast time and position of passage of certain points by the satellite. Measurements are expected to be of sufficient accuracy to determine, through perturbations of the orbit, geodetic

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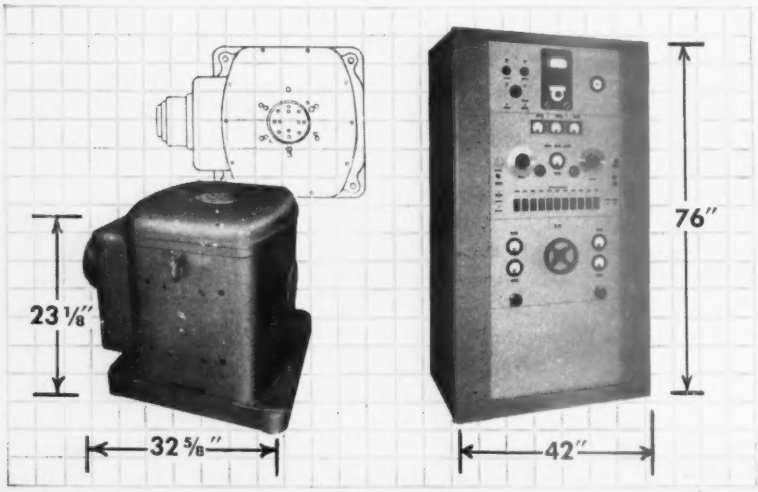


information such as the degree of oblateness of the earth. Perturbation of the orbit caused by atmospheric drag also will make possible a measurement of the density of the atmosphere at the orbit height.

In a paper on "Optical Observation and Orbit Computation Program for the Earth Satellite," F. L. Whipple, Director, Smithsonian Astrophysical Observatory, reported that the observing program consists of two distinct parts. One is the visual search and tracking program of low-order accuracy. The other is the photographic track-program which will be of high precision. The computational program, he said, presents some "challenging problems," all apparently soluble by high-speed electronic calculating machines.

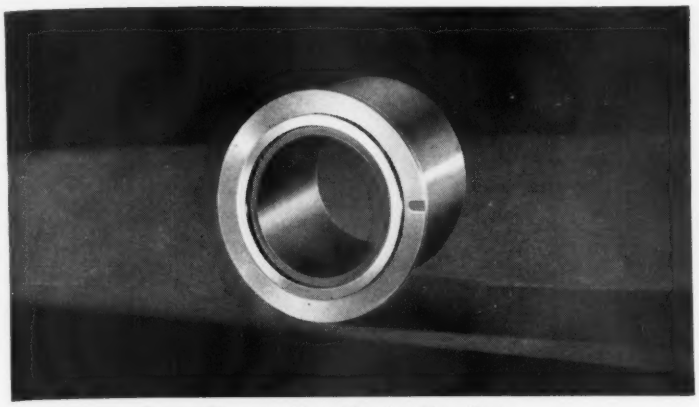
"The Vanguard Satellite Launching Vehicle," by N. E. Felt, Manager, Project Vanguard, The Glenn L. Martin Company, discussed appearance and composition of the rocket, its propellants, and the performance expected of each of its three stages.

Materials—I & II

(In Cooperation with the ARDC, USAF)

Both of these illuminating sessions were conducted under the chairmanship of Brig. Gen. Marvin C. Demler, Deputy Commander, Research and Development, of the USAF's ARDC. The first paper, "Air-Frame Materials," by Major F. C. Krug, Chief, Metallic and Ceramic Materials Section, Materials Branch, Equipment and Materials Division, ARDC, stressed the importance of timely development as regards the attainment of qualitively superior air power. The importance of the length of exposure to conditions of high speeds and altitudes, creep and fatigue, and physical and mechanical properties of current and developmental materials was discussed.

In a paper on "Propulsion Materials," Lt. Col. R. A. Jones, Chief, Materials Bureau, Equipment and Materials Division, ARDC, warned that materials engineers cannot wait for specific requirements but must anticipate needs and assist the



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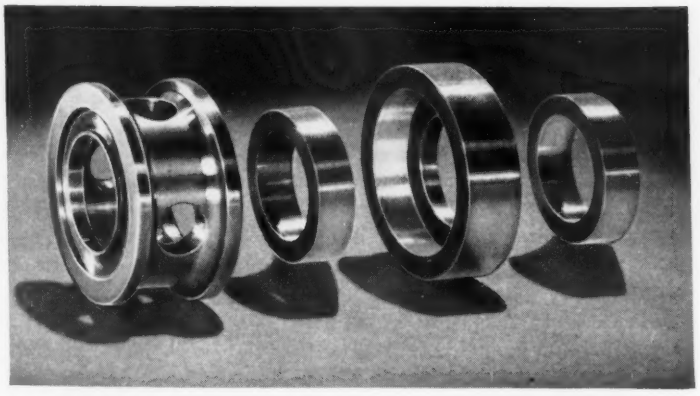

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designers in exploiting rather than tolerating the characteristics of new materials. He said that the key to future improvements in power plants rests with development of heat-resistant materials capable of operation above the current limits of 1,650–1,700°F.

C. W. Kniffin, Chief, Materials Application and Methods Research Branch, Equipment and Materials Division, ARDC, warned in a paper on "Problems in Materials Utilization," that the standard rate of effort in materials research and development has not been able to keep pace with the need in five new types of operational environment. He said that a serious industrial impasse could result unless timely solutions can be effected.

Captain M. H. Brewer, Chief, Preservation Packaging and Miscellaneous Materials Section, Equipment and Materials Division, ARDC, reported that the Air Force research program in elastomer development is progressing in three areas: fluoro-elastomers, modified silicones, and inorganic polymers.

Discussing "Lubricants and Hydraulic Fluids," Lt. Col. L. T. Taylor, Assistant Chief, Equipment and Materials Division, ARDC, predicted that radical changes must take place in "our present thinking with regard to engine oils and hydraulic fluids." His presentation outlined some problems extant and possible approaches to solutions.

Captain A. J. Mione, Assistant Chief, Analysis and Measurements Branch, Materials Laboratory, WADC, in a paper on "Materials in a Nuclear Environment," presented cross sections of data obtained on the effects of nuclear radiation on various classes of materials—crystalline and non-crystalline—to illustrate the magnitude of the problem of radiation in a nuclear-propelled aircraft.

In discussing "Material Approach to Advanced Weapon Systems," H. C. Sullivan, Chief, Analysis and Measurements Branch, Materials Laboratory, WADC, pointed out that certain physical phenomena revealed by study of the thermal environment associated with hypersonic flight conditions could provide the necessary capability—through careful research and development—to overcome what now appear as technical barriers. He advocated a new attitude of material development and said that the "transition from research to engineering must be accelerated by a new type of materials engineer; one who, recognizing engineering requirements, can supply solutions based on a working competence in fundamental sciences."

Medical Aspects of Aircraft Accident Investigation

Dr. John R. Poppen, Capt., (MC) USN (Ret.), was chairman of this session. A means of improving the safety record by use of crash safety design resulting from the biomechanical analysis of survivable-type aircraft accidents was discussed in the first paper. The author, A. H. Hasbrook, Director, Aviation Crash Injury Research, Cornell University, debated "The Biomechanical Analysis of Survivable-Type Aircraft Accidents as a Factor in Improving Safety."

What lies behind "Aero Medical Investigation of Aircraft Accidents" was discussed by Col. H. G. Moseley (MC) USAF, Chief, Aero Medical Safety Division, Directorate of Flight Safety Research. Colonel Moseley pointed out that particular investigation is needed when facts indicate that a pilot's physiological tolerance may have been overwhelmed or where deficiences in his training or application may have caused him to fail to meet the requirements of flying.

A review of the safety organization of the U.S. Navy was reviewed briefly in the paper, "The Flight Surgeon and Aircraft Accidents," by Capt. Carl E. Wilbur, (MC) USN, Head, Aero Medical Section, Aviation Safety Division, Navy Department. The paper was published in last month's issue of the REVIEW.

The session's final paper dwelt on "The Role of the Pathologist in Aircraft Accident Investigations." Three members of the Armed Forces Institute of Pathology prepared the paper: Col. F. M. Townsend, (MC) USAF, Deputy Director; and Capt. V. A. Stembridge, (MC) USAF, and Dr. F. K. Mostofi, Staff Members. The authors pointed out that events have dictated that a detailed pathologic examination of fatal aircraft accidents is necessary in order to evaluate human structural defects that may have played a possible causative role in hitherto "unexplained" accidents. The role of the pathologist and the future of pathology in aircraft accident investigations were discussed.

Meteorology

(In Cooperation with the American Meteorological Society)

The Director of Scientific Service, Air Weather Services, Robert D. Fletcher, was chairman of this session. The first paper, by Isadore Katz, Physicist, Applied Physics Laboratory, The Johns Hopkins University, presented "A Method for Extrapolating Ground-Based Radar Data on Rain Echoes to Areas of Arbitrary Size." Mr. Katz concluded: "For purely meteorological purposes it would be more enlightening if these studies were carried out on a C-band radar. This would lessen the deleterious effects of attenuation."

The hazards of mountain waves as revealed by motorless and powered aircraft were discussed quantitatively in the two-part paper, "Flight Aspects of Jet Streams and Mountain Waves." The first part was by R. M. Endlich and G. S. McLean, and the second part was by J. P. Kuettner, all of the Air Force Cambridge Research Center. Some rules for avoiding more severe flight risks were given.

L. H. Clem, Headquarters, Air Weather Service, USAF, delivered a paper on "Clear Air Turbulence over the U.S." An analysis of data obtained during Project Cloud Trail, a joint Air Defense Command-Air Weather Service project, was presented. Statistics were furnished on turbulence occurring in the layer 25,000–45,000 ft. during the winter season and on other features.

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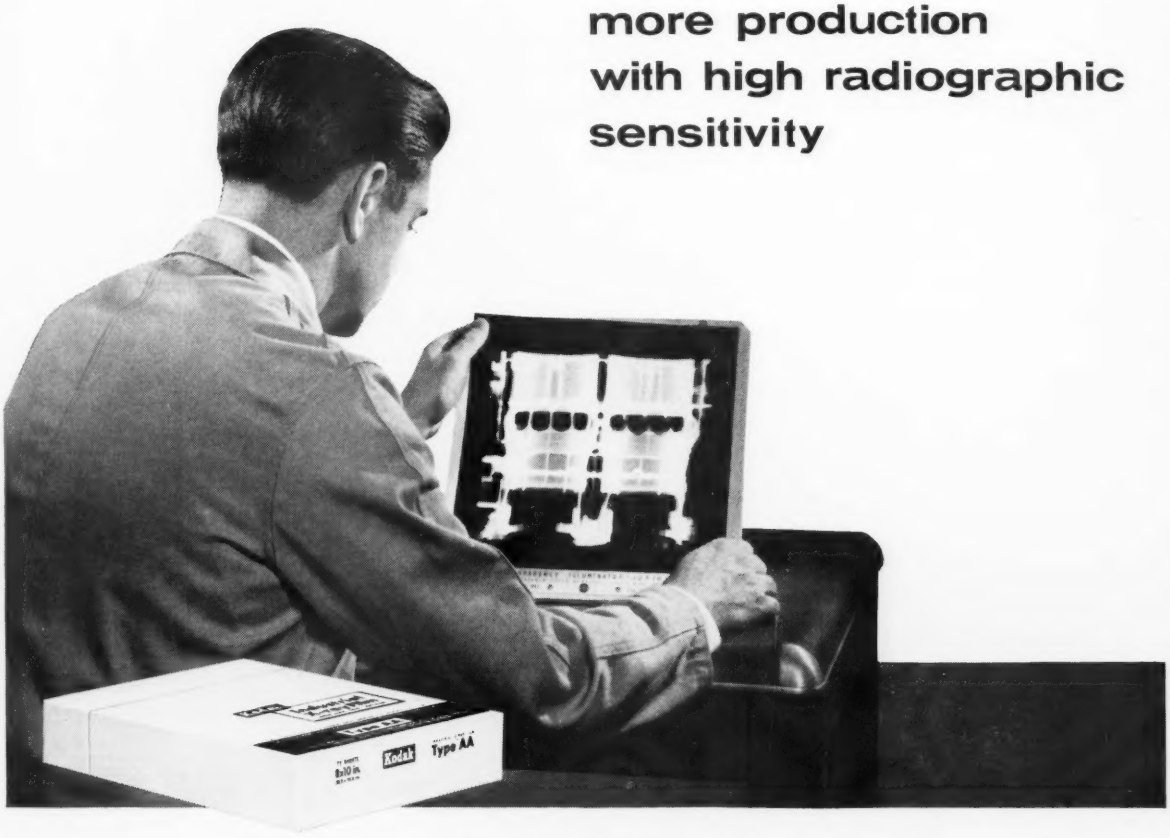

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Kearfott Free Gyros withstand 60 G shock of .0157 secs. duration, vibration up to 500 CPS at 10 G acceleration. Operating temperature range -20° C to +100° C. Weight 5.5 lbs.

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"Threshold Contact Height, A Slant Visibility Measurement" discussed what is meant by this method which is being studied at Neward Airport by U.S. Weather Bureau personnel assigned to the project. Explained were means of calculating the measurement, when a pilot is given the report, and in what manner he participates in evaluating it. The authors were C. G. Knudsen and W. E. Eggert, of the ANDB Newark Project, U.S. Weather Bureau.

Rocket Propulsion

Major General John B. Medaris, Commander, Army Ballistic Missile Agency, Redstone Arsenal, was chairman of this session.

"Modern Developments in Solid Propellant Rocket Engineering" was the subject of a paper by R. D. Geckler and R. E. Davis, Manager and Principal Engineer, respectively, of the Solid Engine and Chemical Division of Aerojet-General Corporation. The study discussed maximum propellant specific impulse, maximum weight fraction of propellant, and environmental conditions.

The paper, "Liquid Rocket Propellants—Is There an Energy Limit?," by J. F. Tormey, Chief—Research, Rocketdyne Division, North American Aviation, Inc., confined itself to consideration of molecular species and the energy derived from their normal chemical, or valence, bonds. The paper concluded that there is an energy limit set up by the natural and inexorable laws of chemistry and physics, "which I am reasonably sure cannot be breached."

The numerous problems that arose around each stage in the development of the propulsive force expected to place the earth satellite in its orbit this year were explored in the paper, "Rocket Developments for Project Vanguard," by M. W. Rosen of the Naval Research Laboratory.

The contributions of the dynamic properties of the thrust chamber, propellant lines, and pumping system to the stability and controllability of the rocket power plant were discussed in the paper, "Effect

small-unit packaging simplifies use and handling of STAINLESS STEEL SAFETY LOCK WIRE

The availability of stainless steel safety lock wire on 1, 5 and 10-pound disposable spools is good news to manufacturers and service organizations in the aircraft, automotive and machinery industries—or wherever safety lock wire is required.

These small-unit spools—now offered for the first time by National-Standard—are expected to simplify many manufacturing and servicing operations, ranging from extensive use of the handy 1-pound hip pocket or toolbox spools in non-localized work, to bench or production uses for the larger spools.

In addition to spools of the 3 capacities, National-Standard offers the lock wire in a complete range of sizes, from 0.020 to 0.067-inch and in five different government specifications: QQ-W-423; AN-W-23; AN-W-24; MIL-W-6713 and AMS-5685-C.

Spools of all three sizes can be mounted on "let-off" spindles and are clearly labeled as to type and size of wire. The 1-pound spools are plastic, the larger spools metal.

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of Dynamic Characteristics of Rocket Components on Control," by three members of the NACA Lewis Flight Propulsion Laboratory staff. They are J. C. Sanders, Chief; David Novik, Head, Section A; and C. E. Hart, Aeronautical Research Scientist—all of the Controls Branch.

Self-Contained Air Navigation Systems

Major General Leighton I. Davis, USAF, Commander of Holloman Air Development Center, Holloman Air Force Base, was the chairman of this session. The session began with a paper on "Operational Need and Use for Self-Contained Navigation Systems." The author was Lt. Col. R. W. West, USAF, Project Officer for Bombing-Navigation Systems, Strategic Air Division, Directorate of Requirements, USAF.

The type of equipment and system needed to provide more continuous and readily available navigation information was discussed, pointing up the limitations of pilots and navigators to accomplish all the functions of navigation using existing techniques.

Essential components and system configurations for guidance within the atmosphere were discussed—along with their effects in system performance—in the paper, "Inertial Guidance," by three scientists from the Instrumentation Laboratory of M.I.T. The authors were Walter Wrigley, Education Director; R. B. Woodbury, Associate Director; and John Hovorka, Staff Physicist. In addition, Mr. Wrigley is Professor of Aeronautical Engineering at M.I.T.

A paper on "Doppler Navigation," by W. J. Tull, Vice-President and Director, Avionic Sales Division, General Precision Laboratory, gave a brief history of work done in the United States to develop Doppler ground speed and drift angle measurement equipment. Advantages credited to Doppler navigation were listed, and a number of uses were suggested by the author.

Stability and Control Problems During Large Maneuvers

The chairman of this session was Waldemar O. Breuhaus, Head, Flight Research Department, Cornell Aeronautical Laboratory, Inc. The first paper was "The Response of a Bisymmetric Aircraft to Small Combined Pitch, Yaw, and Roll Control Action," by R. A. Davis, Engineer, Engineering Division, The RAND Corporation. The complete solution to the equations was presented for a stepped pitch/yaw control action at constant roll rate. The complete solution likewise was given for a variable roll rate, valid only for a simplified system in which the Magnus effect is neglected.

Results of both theoretical and flight-test investigations in an effort by the Flight Research Department of Cornell Aeronautical Laboratory to solve some problems of large-disturbance maneuvering flight were presented in the paper, "A Theoretical and Experimental Study of Airplane Dynamics in Large-Disturbance Maneuvers." Authors were D. W. Rhoads and J. M. Schuler, Research Aeronautical Engineer and Associate Research Aeronautical Engineer, respectively, of C.A.L. Results showed that inertial and aerodynamic nonlinearities introduce distabilizing tendencies not predicted by linear theory.

The third paper of the session was "Airplane Design Implications of the Inertia Coupling Problem," by R. R. Heppe, Department Head, Aerodynamics, and Leo Celniker, Group Engineer, Aerodynamics, both of Lockheed Aircraft Corporation. The paper emphasized the necessity of inertia coupling considerations at the preliminary design stage of development.

A paper on "Cross-Coupling Dynamics and the Problems of Automatic Control in Rapid Rolls," by J. D. Welch and R. E. Wilson, of General Electric Company, reviewed some of the fundamental properties of inertial cross coupling. A simplified method for analyzing the control problem was presented as well as a discussion of the practical problems such as measurement techniques and reliability.

Structures

This session was conducted by Nicholas J. Hoff, Professor of Aeronautical Engineering at the Polytechnic Institute of Brooklyn. The session's initial paper, "The Stability of Thin-Walled Unstiffened Circular Cylinders Under Axial Compression, Including the Effects of Internal Pressure," was prepared by four authors. Representing North American Aviation, Inc., were L. A. Harris and H. S. Suer, Senior Engineers, Structures, and W. T. Skene, Group Leader, Structures Methods. R. J. Benjamin, Senior Aeronautical Engineer, represented Cook Research Laboratories of Cook Electric Company. Developed in the paper was a semiempirical procedure which permits a compressive buckling analysis of cylindrical shells with a knowledge of the cylinder geometry only. The analysis was achieved by correlating experimental data statistically with theoretical parameters.

A solution of the equations obtained by Chien for the nonlinear deflection of shallow spherical shells under uniform external pressure was contained in the paper, "Nonlinear Deflections of Shallow Spherical Shells," by E. L. Reiss, Research Associate; H. J. Greenberg, Associate Professor of Applied Mathematics; and H. B. Keller, Scientist, all of the Institute of Mathematical Sciences, New York University. The solution was obtained by means of power series expansions following procedures introduced by Friedrichs and Stoker in their treatment of buckling of circular plates.

Maurice A. Biot, Research Consultant, Cornell Aeronautical Laboratory, Inc., and Shell Development Company, presented a paper on "New Methods in Heat-Flow Analysis with Application to Flight Structures." New methods were presented for the analysis of transient heat flow in complex structures leading to drastic simplifications in the calculation and the possibility

Painting by Chesley Bonestell from the book *The Conquest of Space*, by Willy Ley and Chesley Bonestell, published by the Viking Press ($4.95). © C.B.

How many Fenwal Controls aboard?

You might make a reservation for the first passenger trip to the moon now. But there are still some things to be determined.

We don't give you a list here of all the Fenwal temperature and control devices that may be found on board. But we do know that our past performance in solving the temperature problems on such a high proportion of modern aircraft will stand us in good stead on solving new problems. And, give manufacturers a good sense of security in adopting Fenwal devices.

For instance, in the field of fire and over-heat detection, Fenwal products are well advanced and proven in both unit and continuous types. Fenwal has the men, the equipment and the knowledge to insure fruitful exploration and practical, trustworthy products for today and tomorrow.

It will be encouraging to find, too, that your engineers will get along fine with Fenwal engineers. Our aircraft catalog on request. It's interesting. Fenwal Incorporated, Aviation Products Division, Ashland, Mass.

Fenwal *Controls Temperature . . . Precisely*

FIRE, OVER-HEAT DETECTORS NO FALSE-ALARMERS

Fenwal Units Detect Real Danger at Once

ASHLAND, MASS. — Every time a Fenwal Unit Fire and Over-Heat Detector gives an alarm, a temperature danger point has been reached that very instant. The unit will not, if properly installed, ground planes with false alarms.

A glance at the design of the Detectors will show why their response to temperature conditions is inevitably prompt and accurate. The stainless-steel shell of each Detector is the temperature-sensitive element. As it expands, it closes contacts hermetically sealed inside.

Shock and vibration cannot disturb the Detectors' accuracy. Neither can temperatures ranging from −85° F to (for short periods) 2000° F.

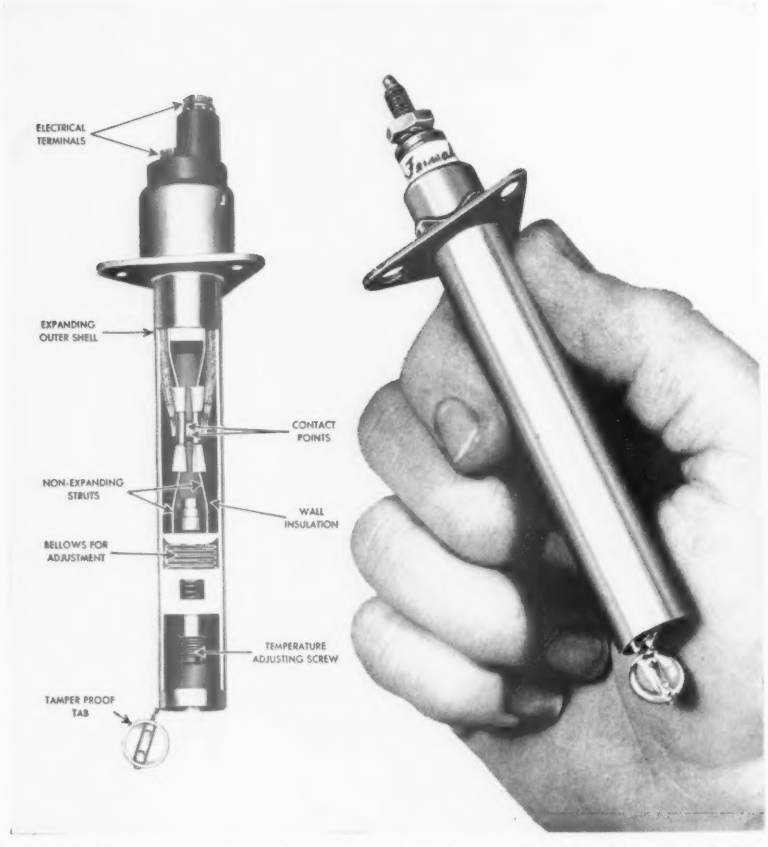
The alarm point is set at any point from 100° F to 1000° F, depending on the model. Some are factory set, others may be adjusted in the field. When temperatures drop below the alarm point, the units automatically reset themselves.

They are designed specifically for aircraft, are both light and compact. Roughly, they are slightly larger than a fountain pen, and the heaviest of them weighs only 3.25 ounces. They are generally equipped with a triangular mounting flange, calling for three holes in a 1.25-inch-diameter bolt circle.

Their current rating is 2 amps, 28 volts, D.C., and there is no need for external relays or costly field adjustment.

They may be had for either single- or double-wire circuits. Each Detector in a system operates independently. Double-terminal Detectors in a double-loop circuit eliminate all possibility of false alarms due to grounding and will operate even with a system fault. Faults in either type of circuit can be detected easily by means of a simple, push-button test.

Fenwal Unit Fire and Over-Heat Detectors meet exacting government specifications. Over many years and with hundreds of thousands of flight hours, they have been thoroughly proven by nearly every major aircraft user and manufacturer. For further details, write to **Fenwal Incorporated, Aviation Products Division, 173 Pleasant Street, Ashland, Mass.**



A TROUBLE-DETECTOR, NOT A TROUBLE-MAKER — You can depend on Fenwal Unit Fire and Over-Heat Detectors for aircraft the way you can depend on Monday's being followed by Tuesday. The reason for this dependability is made clear by the cross-section. The outer stainless-steel shell is the sensing element, and the simple moving parts are hermetically sealed inside.

Fenwal

CONTROLS TEMPERATURE ... *PRECISELY*

of including nonlinear and surface effects. Results were found to be in good agreement with those obtained by the classical and much more elaborate procedures.

The different modes of failure which a box beam will experience under various combinations of statically applied bending moment and duration of heating time were discussed in a paper by J. W. Mar, Assistant Professor of Aeronautical Engineering at M.I.T. The paper was entitled "The Failure of Box Beams Under Bending and Rapid Heating."

The final paper of the session was "Bending and Buckling of Clamped Sandwich Plates," by G. A. Thurston, Technical Engineer, Applied Research Operation, FPL Department, AGT Division, General Electric Company. The paper applied the Lagrangian multiplier method to Hoff's energy expressions for sandwich plates to derive equations for finding the deflections and buckling loads of rectangular plates clamped on all four edges. Buckling coefficients were found and plotted for use as design curves, showing the reduction in buckling load due to shear in the core.

Turbine Propulsion

Hugh L. Dryden, Director, NACA, was chairman of this session. The first paper, "The By-Pass Engine for Transport Aircraft," showed that the by-pass engine may work at higher flame temperatures than the simple turbojet engine with better propulsive efficiencies and, therefore, will give a lower specific consumption and lower weight. Mechanical problems associated with the by-pass engine also were discussed by the authors, A. C. Lovesey, Assistant Chief Engineer, and L. G. Dawson, Chief Project Engineer (Conway), Aeronautical Division, Rolls-Royce Limited.

With the aid of performance data established by aircraft builders, J. R. Szydlowski, President and Director General of Turbomeca, showed the various fields of application in which the basic Turbomeca machine (those utilizing only a single-stage centrifugal compressor) has been used. His paper was entitled "The Importance of Small Gas Turbines in the Field of Aeronautics."

An analytical method for predicting the stall limits of turbojet engine compressors in the presence of rapid transients in engine-inlet pressure or temperature was developed in the session's final paper, "Some Effects of Inlet and Temperature Transients on Turbojet Engines." The authors were D. S. Gabriel, Associate Chief Engineer, Research Division, and L. E. Wallner and R. J. Lubick, Aeronautical Research Engineers, all of NACA's Lewis Flight Propulsion Laboratory.

VTOL-STOL Aircraft

Alexander Satin, Senior Scientific Advisor, Development Planning Department, Lockheed Aircraft Corporation, was chairman of this session.

Effects of wing stall on the power requirements in the transition speed range and on the take-off and landing distance were illustrated in the paper, "Take-Off and Landing Distance and Power Requirements of Propeller-Driven STOL Airplanes," by R. E. Kuhn. Mr. Kuhn is Aeronautical Research Engineer of Langley Aeronautical Laboratory, NACA. It was shown that the proper choice of wing size and propeller disc area, the use of flaps—possibly in combination with wing tilt, and the addition of a slot can all be used or combined by the designer to achieve a considerable measure of control over the wing stall.

▲ ▲ ▲

P. G. Kappus, Manager, New Product Planning, FPL Department, AGT Division, General Electric Company, presented a paper entitled "Power Plants for VTOL Aircraft." Four different VTOL engines were discussed in detail: a turboprop arrangement with a central gas generator powering two pneumatically interconnected propeller turbines with interburner; a four-engine turbojet cluster with cascade jet deflector; a turbofan for hovering, converting into the turbojet cycle for cruise; and a turbofan-powered thrust-supported wingless vehicle.

"The Jet Wing," a paper by J. S. Attinello, Assistant Chief of Research, Fairchild Aircraft Division of Fairchild Engine and Airplane Corporation, reviewed a new form of lift and thrust integration under consideration as a promising solution for STOL aircraft. The author urged extensive research effort on the potential aerodynamic advantages of the "Jet Wing."

General stability and control problems involved in operating a vertical take-off and landing airplane were discussed in the paper, "Stability and Control for VTOL Aircraft," by J. A. O'Malley, Jr., Project, Aerodynamicist at Bell Aircraft Corporation. Various flight paths were considered, and the resulting aerodynamic, gyroscopic, and inertial influences on the airplane during hovering and transition to level flight were discussed.

W. Z. Stepniewski, Chief of Research and Development, and Joseph Mallen, Chief of Design Analysis, Vertol Aircraft Corporation, presented a paper on "Evaluation of VTOL Systems Suitable for Transport Aircraft." Special attention was given to the use of flying test beds as one of the fastest and most economical ways of learning about basic technical and operational problems of VTOL systems.

Lockheed's F-104B is the two-seater "twin" of the ultrasonic Starfighter. It is designed to serve as either a dual-cockpit tactical fighter or a combat-proficiency trainer. Engine, armament, and overall dimensions are the same in both models.

Corporate Member News *(Continued from page 37)*

the limited number provided for in the Navy's fiscal 1954 and 1955 funds have been built.

• **Eaton Manufacturing Company,** Stamping Division, has issued a 16-page brochure describing "Easy-On" caps and filler necks for fuel tanks of all kinds. Copies and information may be obtained by writing to the firm and division at 17877 St. Clair Ave., Dept. R, Cleveland 10, Ohio.

• **Edo Corporation** has announced formation of a wholly owned subsidiary, Edo Ltd., of Canada. The firm has purchased 10 acres near Cornwall, Ontario. Plans call for a new plant to be completed by September.

• **Fairchild Engine and Airplane Corporation's** Engine Division has announced a cooperative engineering student program designed to help alleviate the shortage of trained engineers. Six engineering schools will participate in the program which calls for alternating classroom work with periods of employment in one of the division's engineering groups.

• **The Garrett Corporation . . .** AiResearch Manufacturing Company has developed a twin-motor power assembly that reportedly will allow a jet pilot to override instantly autopilot controls in an emergency. The device permits manual operational control over automatic without any disconnect activity or mechanical clutching mechanism.

• **General Dynamics Corporation, Convair Division,** has opened a European sales office in Geneva, Switzerland. The office is responsible for sales and will support activities of the 880 jet transport and the 440 Metropolitan in European, African, and Middle Eastern areas. The division joined with the ARDC Office of Scientific Research in presenting a symposium on problems associated with space travel in San Diego, Calif., February 18–20. The division reports that the 880 jet transport will employ an "invisible" radio antenna patterned after the flush-type design for military aircraft. The top 4 ft of the vertical fin will be used to send and receive messages while the entire air frame will function as the antenna ground.

• **General Electric Company . . .** A new booklet, *Trends and Developments for Electrical Design Engineers,* that gives information on permanent magnets, thermistors, and thyrite varistors has been published by the Chemical & Metallurgical Division, Metallurgical Products Department. The department has named Allied Carbide Products, Inc., located at Hatboro, Pa., as an authorized Carboloy cemented carbide die products agent. Remco Supply, Inc., Greensboro, N.C., has been appointed a carbide tool distributer. . . . Aircraft Gas Turbine Division engineers have given the T-58 gas-turbine engine a "preflight physical examination" in a special helicopter rotor test stand. The turboshaft engine, qualified to power experimental aircraft, is undergoing flight tests. Two engines were installed in a Sikorsky HSS helicopter for this purpose. . . . Establishment of an Advanced Semiconductor Laboratory in the Electronic Components Division has been announced. . . . Defense Electronics Division engineers have developed a new fuel pump for guided-missile application. It is designed for pumping low-viscosity, low-lubricity, highly corrosive propellant-type fluids.

• **G. M. Giannini & Co., Inc.,** has announced development of a precision Stepping Synchro. The instrument utilizes an electromechanical positioner to drive the rotor of a differential synchro in fixed increments of 1°. It produces an a.c. output that is synchronous with rotor position.

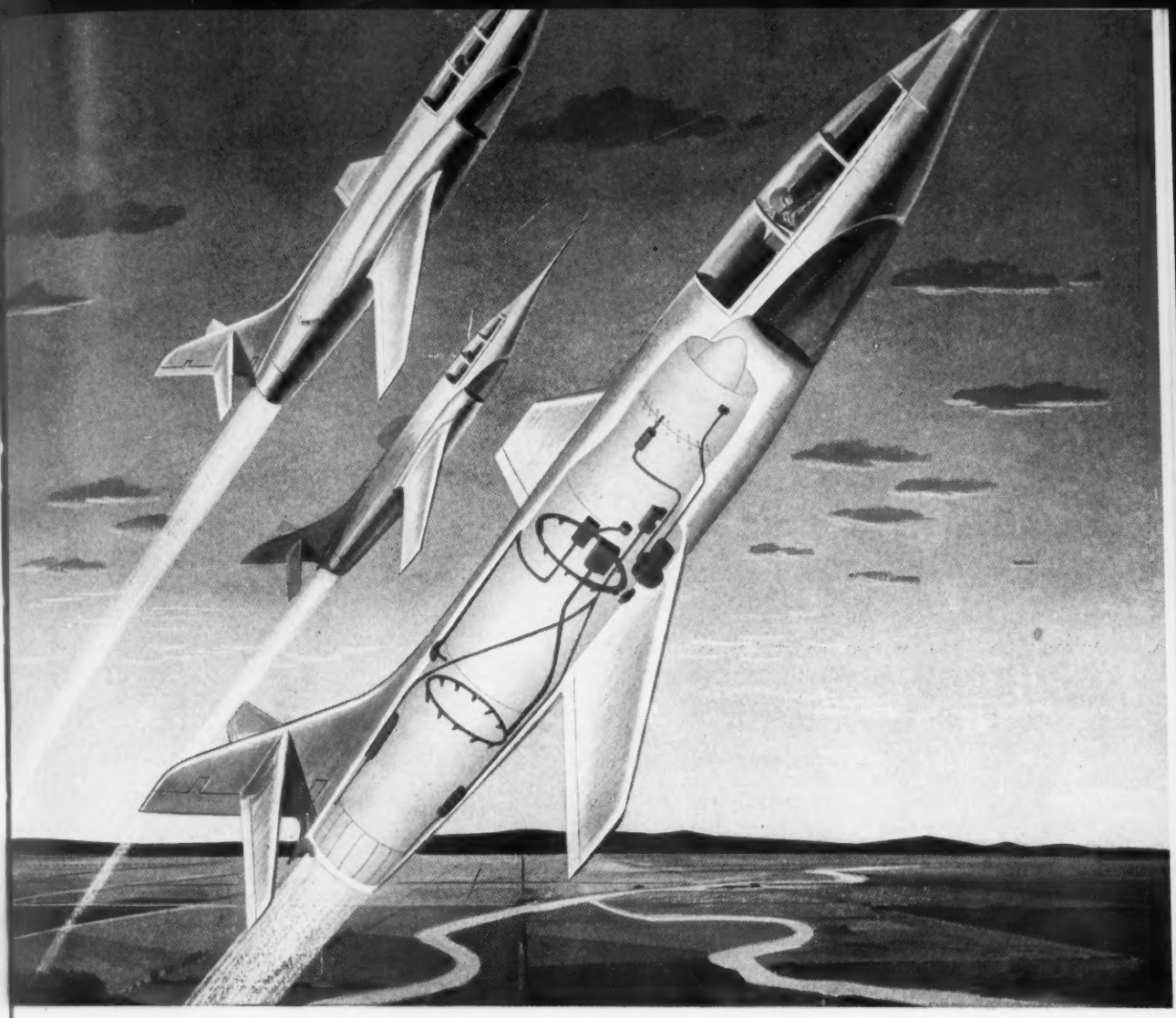
• **Goodyear Aircraft Corporation** has combined services with three other firms to develop a "pillow-tire" vehicle to transport and launch the Matador missile. The vehicle is called the MM-1 Teracruzer and rides on Terra-Tires which use from 3 to 15 lbs. of air and look like huge rubber barrels.

• **Walter Kidde & Company, Inc.,** has published a new brochure which describes the Aviation Division's new device for inflating rubberized fabric gear. The division also has opened a sales-engineering office at the Lambert-St. Louis Municipal Airport, St. Louis, with Eugene A. Hitt, District Manager, in charge. The Industrial Commodities Department has issued a booklet describing lightweight high- and low-pressure steel cylinders.

• **Lear, Incorporated's** Grand Rapids Division has developed a remote positioner for industrial applications called the "Electrolink." The device operates on standard 60-cycle power and, according to the firm, offers rapid response with high accuracy. . . . Lear-Romec Division has manufactured a nozzle for safely servicing fuming nitric acid. The division also is producing a lightweight pump designed for gas-turbine fuel systems. Components include rotary gear, positive displacement with a built-in centrifugal fuel booster pump, and mounting pad for gear-driven fuel meter control.

• **Lockheed Aircraft Corporation's** Missile Systems Division engineers have applied

North American Aviation's X-10, shown in its first photo, is an unmanned test vehicle for the USAF SM-64 Navaho intercontinental strategic guided-missile weapon system program. The vehicle has been flown at supersonic speeds at the USAF Missile Test Center, Florida.



TOWARD MACH 3

WITH A COMPLETE BENDIX SYSTEM FOR FUEL METERING AND ENGINE CONTROL

When the pilot swings the lever from idle to emergency thrust—or back again—things must happen fast in the big jets.

But not too fast!

For, pouring it on, or cutting back faster than the engine can take it, spells disaster. The penalties are ruinous over-temperatures, compressor stall or flame-out.

When the pilot orders a change in thrust, the Bendix* fuel metering and engine control system takes over. Fuel feed is automatically computed and scheduled. Geometric controls such as exhaust nozzle area and inlet vane angles are set. Automatically and instantly, engine response is crowded to the limit—but not beyond!

Matched sets of Bendix components—pressure and temperature sensors, electronic amplifiers, fuel metering units and engine control actuators—work together as a *system*, spanning the length and girth of the engine.

Bendix components, designed and engineered together, invariably give more efficient performance than any arbitrarily assembled system.

And there is the further important advantage of having one source and having that source completely responsible for over-all dependable operation on the plane.

So, when it comes to fuel metering and engine controls, think of a complete and integrated system. Then we suggest you think of Bendix and the Bendix Products Division.

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WE COULDN'T SHAKE ITS ACCURACY

This unretouched photograph shows the Lear Miniature Rate Gyro strapped to a jackhammer, riding side-saddle through two hours of pneumatic nightmare. After this "shakedown run" the gyro still performed up to the most exacting specifications set for the newest Air Force, Navy and Army missiles. This gyro is available right now. How many do you need?

LEAR MINIATURE RATE GYRO

LEAR INC.,
GRAND RAPIDS DIVISION,
GRAND RAPIDS, MICHIGAN

IP-14

an ancient mathematical formula (ascribed to Ptolemy) to solve a communications problem. They report the formula enabled them to eliminate distortion in radio signals sent from a flying missile. Scientists at the division's research laboratory also have worked out a method that reportedly will speed missile development by nearly 50 per cent. It involves feeding a new Univac computer a "diet" of data which the unit "memorizes" and, as a result, simplifies the computer operator's task. . . . Forty-five representatives of major aircraft manufacturers met at the Georgia Division plant to "find better ways for producing airplanes at less cost and in shorter time spans."

• **Minneapolis-Honeywell Regulator Company** has consolidated operations of its Doelcam and Transistor Divisions into a single unit, to be known as the Boston Division. . . . Aeronautical Division engineers have developed a new miniature gyro weighing 8 oz. The unit is said to meet low-drift-rate requirements of short-time or "aided" automatic guidance systems.

• **Norden-Ketay Corporation** has published a bulletin that gives characteristics, drawings, and application data on servomotors. Copies are available by writing to the firm at Commerce Road, Stamford, Conn. The firm also has developed a new digital comparator designed for use in digital servocontrol systems. *Bulletin #418* with specifications describes the device.

• **North American Aviation, Inc.,** has developed a new aluminum casting alloy reputed to be so strong that a square inch could lift ten Cadillacs. Called 42B, it reportedly simplifies the job of producing intricate, completely formed aircraft and missile parts in a single operation.

• **Northrop Aircraft, Inc.,** has established an office at Huntsville, Ala., to represent the corporation and its subsidiary, the Radioplane Company, at Redstone Arsenal.

• **Pan American World Airways, Inc.,** will begin direct, one-plane service to Paris and Rome from Chicago and Detroit on June 2.

• **Radioplane Company** has made first deliveries of its new rocket-propelled target drones to the Navy. The XKD4R-1 is a small plastic aircraft designed as a high-speed, high-altitude training target for air-to-air missile practice.

• **Reaction Motors, Inc.,** has relocated and expanded its Los Angeles office. The move is from 1373 Westwood Blvd. to 10835 Santa Monica Blvd.

• **Republic Aviation Corporation** field service department has estimated that 3.5 million hours have been logged by the firm's jet aircraft all over the world.

• **Ryan Aeronautical Company** has developed a new self-contained electronic automatic navigator, Model 103, for the Army's Electronic Proving Ground. The firm also has announced that construction has started on its Engineering and Laboratories Building. . . . Purchase of machine tools and other equipment of the Fricano Custom Products Company, Inglewood, Calif., and the leasing of its plant and adjacent property was announced. . . . The firm has delivered its first shipment of Ryan Firebee targer drones to the Navy.

• **Servomechanisms, Inc.,** has announced plans for construction of a new million-dollar plant in eastern Nassau County, L.I., N.Y., to house engineering and production operations of the firm's Subsystems Group.

• **Shell Oil Company** has announced plans to add a multimillion-dollar alkylation unit to its Anacortes, Wash., refinery.

• **Sperry Gyroscope Company Division of Sperry Rand Corporation** has announced formation of an Electronic Tube Division. The new autonomous division will perform basic research, development, and production of electronic tubes, klystrons, traveling wave tubes, and related devices. Two more new divisions—the Air Armament Division and a Surface Armament Division—also were announced. Both groups list classified guided-missile projects among current development and production assignments.

• **Stanley Aviation Corporation** has developed a missile scoring device utilizing nuclear energy. This Miss-Distance Indicator detects the radioactive emissions from isotopes inserted in missiles or projectiles and determines the closest approach of the missile to its target. Signals can be telemetered to ground stations or to aircraft. The firm also has been selected as the source of both upward and downward supersonic ejection seats under development by the Industry Crew Escape System Committee.

• **Union Carbide and Carbon Corporation . . .** Haynes Stellite Company Division has published a new booklet on machinery parts made of Haynes alloys. It includes data on chemical compositions, physical and mechanical properties, corrosion resistance, and machining of alloy parts.

• **United Aircraft Corporation . . .** Hamilton Standard Division has issued a new illustrated booklet, *Profiles in Progress*, which discusses in layman's language aircraft air-conditioning systems, turbine-engine starters, fuel controls, hydraulic pumps, pneumatic valves, and electronic temperature controls. . . . Pratt & Whitney Aircraft Division is using a C-124 Globemaster as a flying test bed for its T-57 propeller-turbine engine.

• **United States Rubber Company** has announced the sale of its wire and cable business to Kaiser Aluminum & Chemical Corporation. This includes the plant, property, and equipment in Bristol, R.I. Kaiser also takes over wire and cable inventories, sales organization, and distribution network.

• **Vertol Aircraft Corporation** has announced formation of an operations research group within the engineering division. The group will analyze military missions and commercial operations to find the best way they can be accomplished. The firm also announced that it has taken possession of a third hangar at Philadelphia International Airport.

• **Vickers Incorporated** held a demonstration of a new dynamic test stand for jet-engine fuel controls. The stand consisted of two parts—a test bench where the fuel control was mounted and an electronic console which included a computer sec-

DATA

ON THE NEW LEAR MINIATURE RATE GYRO

RUGGED AND DURABLE—It has been vibrated up to 20 G's and 2000 cps. and submitted to shock up to peaks of 110 G's without significant effect.

UNIVERSAL OUTPUT—Electro-magnetic pick-off supplies 6 volts, 400 cps. into a 10,000 ohm load at maximum rate input. Thus, units of different maximum rates may be interchanged without modification. Unit is also available including integral demodulator in a mounting base for applications requiring a DC signal output.

HIGH ACCURACY—Unit weighs only 1.2 pounds, measures only 1½" diameter by 3⅝" long, yet resolution, threshold and hysteresis closely approach zero rate.

MINIMUM "CROSS-TALK"—Patented design of torsion bar provides previously unrealized cross axis stiffness. Movements in insensitive axes virtually eliminated.

LOW THERMAL NULL SHIFT—Use of thermally compatible materials for all associated parts brings about new lows in the amount of null shift resulting from temperature changes.

UNIFORM DAMPING—Through selection and close control of piston and cylinder materials and damping fluid, the damping orifice varies with temperature to uniformly compensate fluid viscosity variation. Damping is thus maintained at .7 ± .3% critical throughout the operating temperature range of −65 F to + 165 F without the use of heaters.

VERSATILITY—Unit is available with either 26 or 115 volts, 400 cps., 3-phase or 115 volts, 400 cps. split single phase motor. Can be supplied for any maximum rate required. Unit is readily adaptable to requirements involving different signal outputs and damping characteristics. 2 and 3 axis packages also available.

LEAR

tion. The firm also announced that its second annual Jet-Engine Hydraulics Symposium will be held in Detroit, April 22–24. . . . A new district office for aircraft products sales and service has been opened in Seattle.

• **Western Gear Corporation,** Electro Products Division, has announced availability of Model 7PO1 single- or multiple-channel strain-gage power supplies.

• **Westinghouse Electric Corporation** scientists have developed a new technique for taking pictures of the atomic "insides" of metals and other crystalline materials. It involves a new means for detecting neutron "bullets" which are shot through the crystal—an improved method of making the neutrons visible to a photographic film. The firm's air arm division is on a program to reduce the weight and size of air-borne computers. The division also has designed a radar coupler for operation at 400°F. The unit couples a fire-control system to the automatic pilot to zero an airplane in on its target.

• **Wyman-Gordon Company** has bought the Prex Corporation of Chicago and plans to double the work force as soon as a new plant is completed. Prex makes close-tolerance, small aluminum forgings.

IAS SECTIONS

Atlanta Section

Craig Timmerman, Director, Air Navigation and Traffic Control Division, Air Transport Association of America, spoke on "Traffic Control for Turbine Aircraft" before 71 members and guests at the January 3 dinner meeting.

He began with a description of the evolution of traffic control system in the early days of flying. He said there was little concern about en route separation of planes because early operations were of relatively small volume and used mostly visual navigation. Instrument flying changed this picture and brought about recognition of the need for controlled airways. Air lines established their own control system and created a separation standard to solve the problem.

The Government assumed responsibility for airway control in 1937 and, through the CAA, expanded the airway system and took over control-tower operation as a Government function. After the introduction of radar this system was further expanded and based on the use of new equipment.

Postwar expansion of air-line and military operations in magnitude and speed has brought about a saturation of existing control facilities, he said. The CAA and other interested agencies in conjunction with military services are striving to develop new control techniques to handle the present and projected volume of operations. Among techniques proposed is elimination of manual recording of data on flight progress boards, new data transfer equipment, new radar beacons, and new schemes for handling communications between control centers and flying aircraft.

Lack of trained personnel to man new and existing control facilities is currently a serious deficiency, Mr. Timmerman said. Training classes are under way, but some time must elapse before students have accumulated experience necessary to handle the complex task of controlling modern high-speed planes.

Mr. Timmerman concluded that current control systems are safe but must be radically expanded to prevent the present delays existing during periods of inclement weather and to handle future growth in operations.

Chicago Section members watch operation of an electronically controlled camera developed by Chicago Aerial Survey Company. Some 30 members toured facilities of Chicago Aerial Industries, Inc., on January 9.

Chairman W. R. Rhoads announced the following appointments: Edith Lively, Publicity Committee Chairman; E. I. Bricker, Representative to the Architects and Engineers Institute; F. A. Cleveland, Head—Long-Range Plans and Activities Committee; E. S. Williams, Chairman of the Educational Committee; W. C. Emory, Membership Committee Chairman; and G. K. Williams, Chairman of the Nominating Committee.

CLAUDE V. WILLIAMS, *Secretary*

Chicago Section

Some 30 members and guests toured facilities of Chicago Aerial Industries, Inc., and Chicago Aerial Survey Company on January 9.

Aerial Survey has contributed to development of thin-wall magnesium castings, reducing wall sections from 1/4 to 1/8 in. without corresponding reduction in strength.

Automatic and semiautomatic electronic systems controlling lens opening and shutter speeds for as many as twelve cameras in one aircraft were explained The cameras are controlled by a push button, and malfunction of one camera does not impair operation of the others.

Use of photography in photo-indexing and topographic mapping was explained from a composite photo of Chicago made of 1,400 individual photos taken at 1,600 ft. These were spliced together and assembled with about a 60 per cent overlap.

Members also inspected the Environmental Laboratory and its equipment. Work at the lab was explained with reference to meeting Government specifications.

Five members of the Section are with Aerial Survey: Fred Sonne, firm President, and Eugene Elliott, George Maglietta, Miles Mray, and Anthony Tamosaitis.

R. F. HUNTER, *Secretary*

Cleveland-Akron Section

More than 300 members and guests toured the NACA Lewis Flight Propulsion Laboratory's large supersonic wind-tunnel facilities on January 15. After the tour Melvin N. Gough spoke on "Some Sidelights on Modern Flight Research."

Tours were organized at 5:30 p.m. to visit the facilities. Members saw the 8- × 6-ft. supersonic tunnel that has a variable speed range through transonic up to twice the speed of sound. The new transonic modification to the test section was inspected with its 4,700 1-in. diameter holes drilled through the 1-in. thick stainless steel walls at an angle of 60 deg. to the surface normal. The 10- × 10-ft. tunnel driven by 250,000 hp. is the largest propulsion tunnel in operation and has a speed range of from 2 to 3½ times the speed of sound.

At a social hour and dinner meeting, Edward R. Sharp, 1956 IAS President and Director of the Lewis Lab, served as Honorary Chairman and introduced Mr. Gough who is Chief—Flight Research Division, NACA Langley Aeronautical Laboratory.

The first portion of his talk centered on the history of flight research and included many interesting points in connection with the Wright brothers' experiments. He said the supersonic aircraft of today require great coordination between wind-tunnel experiment and flight research program.

Mr. Gough outlined in detail the types of programs and highly complicated instrumentation and planning required for effective flight research. Topics covered were aerodynamic heating, load distribution, gustiness at extreme altitudes, aeroelastic effects, stability and controls, control safety margins, and others. His discussion included problems in high and low-speed flows.

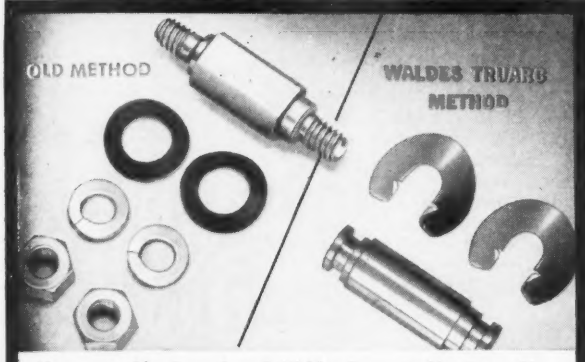
He ended his talk with a research report on friction experiments with landing tire and runway. This was illustrated with movies of B-29 landings with high rates of vertical descent and interesting equipment for studying runway contact wheel acceleration.

JOHN C. EVVARD, *Secretary*

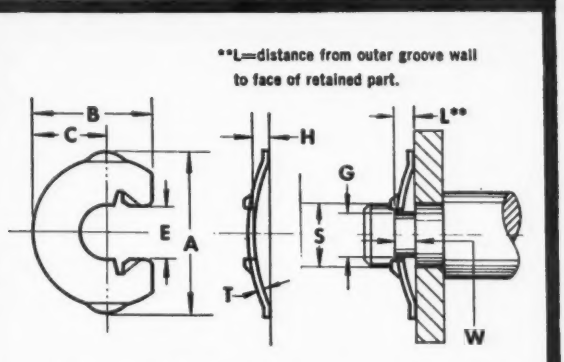
Dayton Section

Captain Sheldon W. Brown, USN, Director of Production Division, BuAer,

New Waldes Truarc locking-prong ring functions as spring, shoulder, fastener...and STAYS PUT!



Above assembly shows how 2 Waldes Truarc Locking-Prong Rings (Series 5139) replaced 6 parts...eliminated threading operation... and need for skilled labor.



WALDES TRUARC LOCKING-PRONG RING (Series 5139)
U. S. Pat. Pending

Ring No. 5139-	SHAFT Dia. S	tol.	RING DIMENSIONS A	tol.	B	tol.	C	tol.	E	tol.	H	tol.	T†	tol.†	average ultimate shear strength lbs.*	GROOVE DIMENSIONS Dia. G	tol.	Width W	tol. −.000	L min.	L max.	resilient end play take up L max−L min
12	.125	±.002	.340	±.010	.307	±.010	.166	±.005	.086	±.004	.050	±.010	.010	±.0013	400	.082	±.0015	.045	+.005	.035	.045	.010
★15	.156	±.003	.380	±.010	.330	±.010	.184	±.005	.108	±.004	.055	±.010	.010	±.0013	600	.104	±.002	.050	+.005	.035	.045	.010
18	.188	±.003	.445	±.010	.390	±.010	.213	±.005	.130	±.005	.060	±.010	.015	±.0015	900	.124	±.002	.065	+.005	.045	.055	.010
25	.250	±.003	.581	±.010	.500	±.010	.280	±.005	.172	±.005	.070	±.010	.015	±.0015	1000	.165	±.002	.070	+.005	.050	.065	.015
31	.312	±.003	.744	±.010	.620	±.010	.360	±.005	.234	±.005	.095	±.010	.018	+.001 −.002	1300	.228	±.003	.080	+.005	.080	.095	.015
★37	.375	±.003	.853	±.015	.740	±.010	.427	±.005	.280	±.005	.130	±.010	.020	±.002	1900	.270	±.003	.105	+.005	.090	.115	.025
★43	.438	±.003	.960	±.020	.820	±.020	.475	±.010	.327	±.010	.130	±.010	.020	±.002	2200	.327	±.003	.105	+.005	.095	.120	.025

Additional Sizes Under Development ★Production dies not available as of date of printing †Applies to unplated rings only *Recommended safety factor =3 to 4.

The Waldes Truarc Locking-Prong Retaining Ring is a new, low cost, radially applied fastener which can be locked positively in its groove and used as a shoulder against rotating parts. It is primarily intended for use in the automotive, electronic and aeronautical industries.

This radially applied ring locks positively in its grooves by means of two prongs at the open end. Because of its high thrust-load capacity the Waldes Truarc Locking-Prong Ring may be used as a shoulder against rotating parts. Its bowed construction provides for end-play take-up in the assembly and makes less critical the tolerances required for the parts being fastened. Since it serves as a spring as well as a shoulder, this ring eliminates the need for springs, washers, and other accessory fastening devices.

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WALDES TRUARC Retaining Rings, Grooving Tools, Pliers, Applicators and Dispensers are protected by one or more of the following U. S. Patents: 2,382,948; 2,411,426; 2,411,761; 2,416,852; 2,420,921; 2,428,341; 2,439,785; 2,441,846; 2,455,165; 2,483,379; 2,483,380; 2,483,383; 2,487,802; 2,487,803; 2,491,306; 2,491,310; 2,509,081; 2,544,631; 2,546,616; 2,547,263; 2,558,704; 2,574,034; 2,577,319; 2,595,787. and other U. S. Patents pending. Equal patent protection established in foreign countries.

spoke on "Some Complexities of Spending Money for Military Aircraft" at the January 24 meeting.

Captain Brown divided the various kinds of decisions affecting and influencing procurement of military aircraft and related equipment into four major areas: What to Buy, How Many, When, and From Whom. Each area was analyzed and the nature of requirements examined.

Factors determining What to Buy, he said, include the state of the art, kind of war, military characteristics, foreign progress, financial impact, and interservice cognizance. Similar breakdowns were applied to other areas.

He stressed complications imposed by procurement laws and regulations, budgeting processes, frequent changes in aircraft programs due to development progress, and the changing international scene.

Morale factors, such as enthusiasm for a particular manufacturer's product, were presented as having an important though intangible effect on the From Whom area.

Captain Brown cited methods that contractor's employ to aid Government procurement processes and acknowledged their valuable contributions in this area.

W. E. STANGER, *Secretary*

STOL-VTOL Aircraft

Hagerstown Section

A panel discussion on STOL and VTOL aircraft highlighted the January 15 meeting.

Moderator was R. A. Darby, Chief Research Engineer, Fairchild Aircraft Division. On the panel were Capt. J. W. Klopp, USN, Chief of Airframe Design, BuAer; Col. G. P. Seneff, USA, Office of Chief of Research & Development Command; N. M. Stefano, Chief of Rotary Wing, Fairchild; Walter Tydon, Chief Engineer, Fairchild; and Lt. Col. C. G. Strathy, USAF.

Captain Klopp said there are different approaches to meet the mission requirements for this type of aircraft, but only a few will survive. From 50 to 60 helicopter designs fabricated in backyards, only a few survived. He said requirements will help determine configurations and that low-speed performance is being stressed on a high priority.

Colonel Seneff said the Army is conducting many tests to compare and evaluate VTOL as against STOL aircraft and that the Army needs the helicopter's agility.

Colonel Strathy felt the VTOL is much further away than STOL and will probably be of the tilt wing or engine type with the fuselage horizontal during initial ascent. He said problems of dispersement and logistic support can be met better with VTOL aircraft.

Mr. Stefano said the helicopter is here to stay. Its survival characteristics over competitive new configurations are ability to hover for long periods with relatively low fuel consumption, ability to make a safe power-off landing in a highly restricted area, and low downwash velocity. He said both types of aircraft will be in service in about 8 years. These will be turboprop, by-pass engine, and pure jet.

Mr. Tydon believes that we have reached the point where theoretical data are of questionable value and that hardware tests are needed for further progress. Power plants for BLC systems are not available, not even on paper yet. Problems associated with hardware must be tackled as soon as they are determined.

Some 40 members at the meeting engaged in a question and answer session after the panel discussion.

R. W. BRADHAM, *Secretary*

Hampton Roads Section

Members at the January 15 dinner meeting heard John H. Collins, Jr., describe recent developments in aero-

Panel members who discussed STOL and VTOL aircraft at the Hagerstown Section January 15 meeting are Walter Tydon, Chief Engineer, Fairchild Aircraft Division; N. M. Stefano, Chief of Rotary Wing, Fairchild; Lt. Col. C. G. Strathy, USAF; Capt. J. W. Klopp, USN, Chief of Airframe Design, BuAer; Col. G. P. Seneff, USA, Office of Chief of ARDC; and Moderator R. A. Darby, Chief Research Engineer, Fairchild.

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Electronics Liaison Engineer. To provide engineering assistance to manufacturing and laboratory units on electronic assemblies. Degree in mechanical or electrical engineering required.

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Senior Structures Loads Engineer. To determine air and ground loads and airframe temperature distributions; to analyze aircraft performance relative to shipboard operation; to determine repeated load criteria of aircraft components. Requires degree in engineering, applied mathematics, or physics, plus three or more years experience in aircraft loads, applied mathematics, or applied mechanics.

★

Statistical Analyst. To determine system reliability from component failure rates. Requires knowledge of statistics and probability and a degree in statistics, mathematics, or in a related field.

To arrange for a personal interview, or for a prompt report on these openings, write to:

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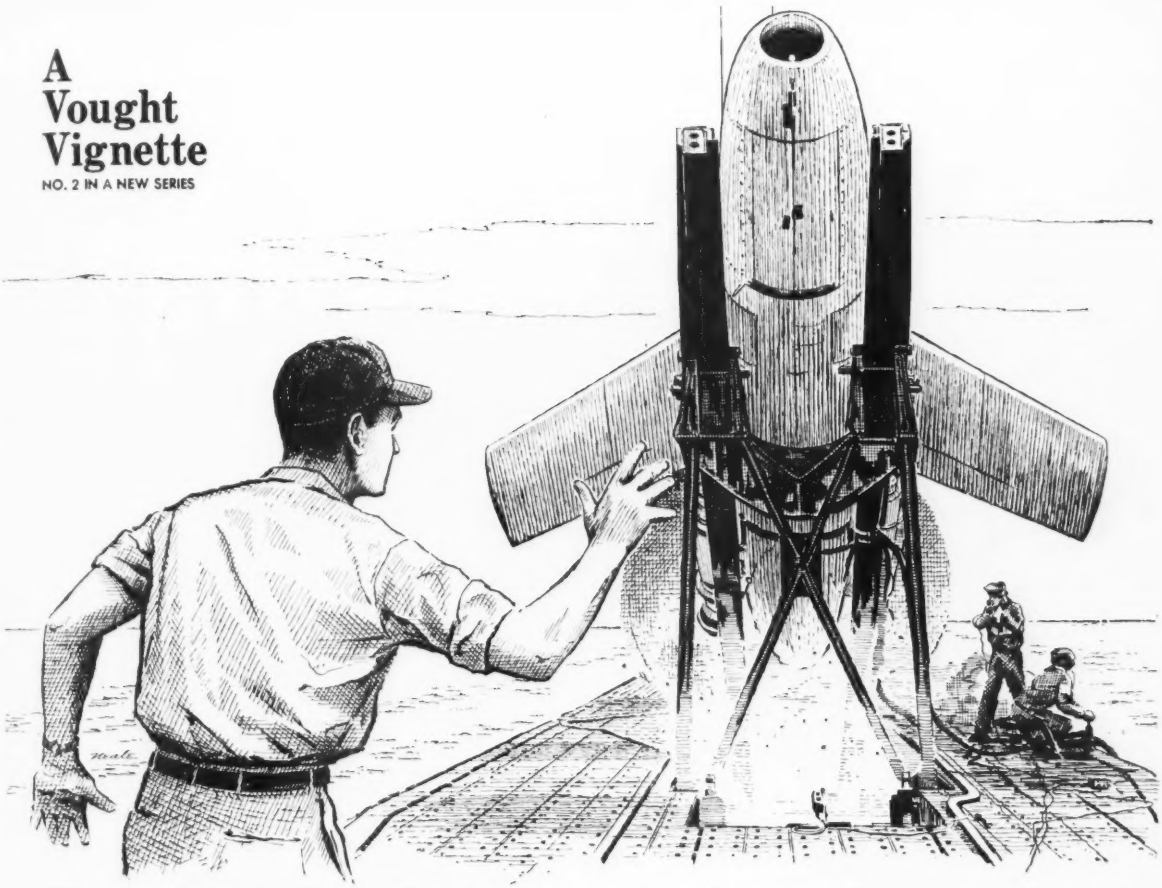

The Missile Engineer with undersea legs

Jack Welch felt honored when he was tossed, fully clothed, into the Navy's sub harbor at Port Hueneme, California. In their own rugged way, submariners were extending him their thanks. He'd been a big help in the introduction of Chance Vought's Regulus I missile to the Navy's Undersea Fleet.

Months before his ceremonial splash, Jack had accompanied the Regulus aboard the submarines *Tunny* and *Barbero* as a representative of Vought's Missile Operations Engineering Group. A veteran of the Regulus flight test program and a collaborator on the conversion of the subs to missile carriers, Jack brought knowledge the Navy welcomed. Likewise, the Navy crews were to share with Jack some equally valuable experience.

Jack, with the submarines *Tunny* and *Barbero*, cruised the East and West Coasts, performed over 200 dives, and once prowled far west of Hawaii. The missile man helped the undersea crews complete initial checkouts of Regulus support equipment — culminating in the first missile launch ever made from a submarine. Then they went about solving environmental and supply problems that arose during tests. Jack added to his mechanical engineering experience a valuable store of electrical, weapon systems and Navy knowledge.

Back in home port, on the *Tunny's* quarter-deck, with a full crew assembled, submarine officers reviewed Jack's contributions. He'd gone beyond his duty as a technical advisor, they concluded. He'd become an expert submariner as well. In fact, he'd qualified for the Silent Service's Gold Dolphin insignia . . . and all hands would proceed at once with the traditional initiation. That's when Jack took his plunge.

Today, Jack divides his time between Chance Vought and a half-dozen Navy shipyards. His job is to see that current missile and ship design is meeting the missile needs of the Fleet. Problems are many, but Jack maintains there's a solution for each. "That's a lesson I learned from the submarine forces," he said. "They gave me a real indoctrination in a can-do attitude under actual operating conditions."

At Chance Vought the missile engineer belongs to a team that already has experienced every conceivable missile problem, from development to operational readiness. Here, current assignments range from theoretical work to the introduction of complete missile systems to the Fleet.

CHANCE VOUGHT AIRCRAFT
INCORPORATED · DALLAS, TEXAS

nautics in the countries of western Europe. Mr. Collins, Assistant to the Director of NACA's Lewis Flight Propulsion Laboratory, toured Europe during 1956.

The British, he said, are proud of their accomplishments in engine and aircraft development—and justifiably so. He cited several high-performance engines and supersonic airplane prototypes made in Britain but expressed the thought that the British know little about large-scale manufacture. Many parts for engines are turned out by slow hand processes.

Mr. Collins said the French are imaginative designers and pointed to the Leduc ram-jet as an illustration.

He said the NACA is highly respected in all European countries as the foremost aeronautical research agency. In Europe NACA reports are studied thoroughly and used continually as references.

▶An illustrated talk on aerodynamics was presented by E. C. Polhamus and W. C. Hayes, of the Section's Student Activities Committee, at George Washington Carver High School in Warwick, Va. The talk, given in December, was in connection with the Section's program to encourage the pursuit of scientific studies.

Some 200 eighth-grade students ended the aerodynamics part of their general science course with this program. Slides and movies were used to show the history of flight, from man's earliest concepts to the development of lift and flow fields around airfoils and wings.

A color film described research at different NACA laboratories. The program concluded with a question and answer discussion.

Members of the school science faculty were given copies of the IAS booklet *Your Career as an Engineer in Aviation* for distribution to students.

RICHARD T. WHITCOMB, *Secretary*

Weapons Systems Analysis

Niagara Frontier Section

Some 50 members heard Robert H. Shatz speak on "A Discussion of the Objectives and Techniques of Weapons Systems Analysis" at the January 16 meeting in Buffalo. Mr. Shatz is Head—System Research Department, Cornell Aeronautical Laboratory, Inc.

He began by defining weapons systems analysis as the explicit use of scientific methods as an aid to military decision making and then outlined the field.

Two main factors make analysis a necessity: the rapid change in technology and the current power struggle between the East and West. He said three points to be kept in mind in making an analysis are:

(1) Science and technology provide a bewildering number of possibilities, to the extent that too many systems are available for all to produce economically.

(2) The analysis must make it possible to make an intelligent selection from all these possibilities.

(3) It is necessary to predict future developments.

Mr. Shatz briefly described historical development of operational research techniques to show the development of methods and their employment in selection of weapons system. Objectives of an analysis are to assist in selection and development of future weapons systems, improve present systems, help create future systems, and improve and formalize methodology of the overall field.

He said a specific analysis may be divided into four parts: study of weapon system requirements, comparative evaluation of competitive systems, tactical and strategic employment of the system, and creation of a system specification and conceptual design.

Common-sense rules that have proved of value to the analyst are:

(1) Develop as precise a problem statement as possible, and invent some measure of effectiveness.

(2) Make numerical assumptions of weapon availability and a timetable for its development (assume several values and test for sensitivity through wide variation).

(3) Assume the system works, although there may be technical uncertainty, and ask, "What good is it?".

(4) Create a system model to determine the interrelation of complex factors.

(5) Remember that answers obtained with these techniques are relative rather than absolute and that small differences in results are unimportant.

Two methods are possible for determining complex factor relationship: Create a large symmetrical model including everything on both sides, or devise a small model consisting of chunks of overall system by factoring and break-

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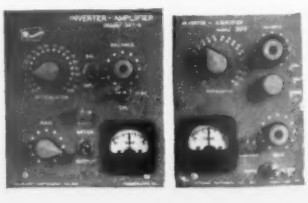

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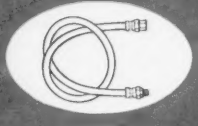
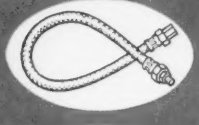
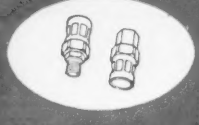


TEFLON HOSE
Teflon hose and hose assemblies are offered for use where chemical and temperature resistance and light weight are required.



FITTINGS
Reusable, pressed on, clamp type, flange type, S.A.E. and special fittings and couplings are manufactured for all services.



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ing the system down into the subproblems.

For improving weapon system analyses Mr. Shatz recommended standardization of the general system of analyses, provision for more open discussion of methods, and emphasis on fundamental methods research.

A discussion period was held after the lecture.

RONAL B. CRISMAN, *Secretary*

Radio Astronomy Explained

San Francisco Section

Ron Bracewell, visiting Professor of Electrical Engineering at Stanford University, explained the role played by radio astronomy in upper atmosphere research at the January 17 meeting.

Dr. Bracewell said the density of matter beyond the limits of the earth's atmosphere has proved to be quite sizeable and that the earth and other planets of the solar system are actually imbedded in the atmosphere of the sun. Particle densities of from 10^3 to 10^5 per cu.cm. characterize this region compared to densities of about 3 to 10 particles per cu.cm. in deep space.

Dr. Bracewell described effects of solar disturbances on radio communications and noted that success has been achieved in the last few years in predicting time and severity of such communication failures.

He described the phenomenon of "whistlers" saying that they are disturbances created by lightning strikes that leave the earth's atmosphere, travel along lines of magnetic force for tremendous distances, and return to earth as a whistling sound that can be detected with an audio amplifier. Incoming disturbances are reflected by the ionosphere back along magnetic lines, returning to their origin where they again produce a characteristic whistle. Many IGY installations around the world are being activated to study "whistlers."

New Section officers installed at the meeting were Russell G. Robinson, Chairman; Stanley Moy, Vice-Chairman; Jack Bert, Treasurer; and Robert M. Crane, Secretary.

ROBERT M. CRANE, *Secretary*

Texas Section

A "Flying Safety Symposium" specialist meeting was held January 23 in the Engineering Auditorium of Arlington State College.

Panel members were M. E. Collis, Chief of Test and Evaluation, Temco Aircraft Corp.; J. W. Lankford, Staff Experimental Test Pilot, Chance Vought Aircraft, Inc.; E. J. Smith, Chief Experimental Test Pilot, Bell Helicopter Corp.; and C. E. Bledsoe, Design Engineer, Escape Personal Equipment Section, Convair, A Division of General Dynamics Corporation. Moderator was C. O. Miller, Staff Engineer, Cockpit Design and Flight Safety, Chance Vought.

Each panel member presented safety problems peculiar to his particular aircraft. These formal presentations were followed by a brisk question and answer session, with an audience of some 40 engineers participating.

Main concern of most panel members was survival under extreme circumstances. The possibility of some safety devices causing the failure of other safety devices was discussed. Design for foolproof assembly and structural integrity also was emphasized.

▶Walter LaBerge lectured on "Missiles—Past, Present, and Future" at the Section's annual joint dinner meeting with the SAE on January 11. Dr. LaBerge is Technical Head—Missiles Design Development Branch, Naval Ordnance Test Station, China Lake, Calif.

He discussed missile history, operating principles, and possible future developments. After the talk a recent movie of the Sidewinder was shown.

Some 180 members and guests of the IAS and SAE attended the meeting.

A. T. CLEMEN
Secretary

Twin Cities Section

New officers elected in December were Thomas W. Chase, Chairman; Robert Holdahl, Vice-Chairman; Edward Abramson, Corresponding Secretary; Arthur Jones, Recording Secretary; and Paul Leland, Treasurer.

HERBERT JOHNSON
Secretary

Washington Section

Edgar Schmued, Vice-President—Engineering, Northrop Aircraft, Inc., spoke on "Progress in Low Drag Boundary-Layer Control" at the January 8 dinner meeting. Brigadier General H. F. Gregory, USAF, Office of Scientific Research, was Honorary Chairman.

Mr. Schmued's paper, which appeared in last month's REVIEW, traced development in the field and reviewed experiments of Dr. Pfenninger in Switzerland and at Northrop, of Professor Raspet at Mississippi State College, and of Dr. Lachmann in England.

G. L. DESMOND, *Secretary*

Wichita Section

"The Cessna 620" was described by Ralph Harmon, Chief Engineer—Business Transport Division, The Cessna Aircraft Company, before 205 members and guests at the January 9 dinner meeting.

He covered the design, fabrication, and testing of the business transport. A thorough study and analytical application went into the 620. Digressions on problems which arose during fabrication and testing not only were warmly received but were appreciated as the type of instance which enriches a project's history and contributes to a company's experience.

Cessna sponsored a social hour before the meeting.

EDWARD J. SULLIVAN, *Secretary*

STUDENT BRANCHES

Boston University

A discussion of the CAA—its operations and opportunities—was featured at the December 11 meeting. Guest speaker was Edwin C. Marsh, Chief of the CAA Aircraft Engineering Division.

Mr. Marsh said that the primary role of the CAA is to promote and ensure safety in the air. He said five necessities of safe flight are airworthy vehicles, competent airmen, adequate navigation aids, controlled traffic flow, and well-equipped airports.

Each necessity was explained and improvements which could be added to existing standards discussed. Emphasis was placed on accident investigation and lessons learned from it.

After the talk, an audience discussion period was held and a short film on the Sabre jet was shown.

FRANK H. BICHOLS, *Secretary*

California State Polytechnic College

A demonstration by Albert I. Moon of Aerophysics Development Corporation nearly smoked out the Branch when several samples of solid rocket fuel were ignited at the last meeting.

Mr. Moon was demonstrating the burning rates of different solid propellants, part of a talk on "Guided Missiles and Research Rockets." He gave an overall view of the missile field, flight-testing procedures, and his firm's hypersonic test vehicle. Films of the Dart antitank missile and the hypersonic vehicle which hits Mach 7 in the first 2 sec. of flight were shown.

▶ Chuck Durand of Grand Central Rocket Company spoke on "Solid Propellant Rockets" at the November 15 meeting. He discussed the growing importance and advantages of solid-propellant rockets.

▶ November 6 was the date set by world-wide flying saucer experts for the appearance of the craft over San Luis Obispo, home of this school. Members of the branch sent up a "pursuit" plane which was coupled with several radio-equipped ground observers, radio station KATY, and radar equipment during the hour the saucers were to appear. After several hours, much excitement, controversy, and false alarms, it was decided that the "Martians" were not coming.

▶ Captain Robert Hippert of Edwards AFB spoke on "Flight Test Procedure" at the October 18 meeting. He described the tests aircraft must pass before being accepted by the Air Force.

▶ New officers introduced at the October 12 meeting by Chairman Lee Beckwith were Warren Dolezal, Vice-Chairman;

Herb Chelner, Corresponding Secretary; Steve Parrish, Recording Secretary; and Ray Ulyate, Treasurer.

E. W. Robischon, IAS Western Region Manager, spoke on "What the IAS Means to You," pointing out that membership in the Institute is an asset in obtaining employment after graduation. He said the progress of an engineer in his job parallels the progress of his activity in the IAS. A question period after the talk brought out many functions of an active IAS member.

Two films, *Photo Squadron* and *Operation Ski Lift*, were shown. The first dealt with the importance of aircraft in a photo reconaissance squadron; the other film illustrated problems of arctic flying.

WILLARD D. HIMEBAUGH, *Secretary*

Georgia Institute of Technology

A report on the progress of papers being written for the Southeastern Student Conference was given at the January 21 meeting. Two papers will be presented from this branch.

Eleven new members were conditionally accepted and a social function was planned in cooperation with Sigma Gamma Tau fraternity. A bill for $100 was received for two pages taken by the Branch in the school yearbook.

After the business meeting three films were shown: *Airpower, Chapter IV; Airpower, Chapter VII;* and *I Saw It Happen*, a story of flight from the Wright brothers to date.

EUGENE C. KNOX, *Secretary*

Indiana Technical College

Officers elected at the January 8 meeting were Richard Bender, Chairman; Dwane Hoffman, Vice-Chairman; Russel Rhodes, Treasurer; and Jack Boccaleoni, Secretary.

▶ At the December 18 meeting $87 was donated to buy gifts for a needy family.

▶ Roger Bingham, Supervisor of Wind Tunnel Operations at Chance Vought Aircraft, Inc., spoke on "The Low-Speed Wind Tunnel" at the December 4 meeting. He explained construction and operational procedures of the tunnel. Thirty-five members attended the meeting.

NORMAN L. BEELER, *Secretary*

Iowa State College

Russell O. Walters of the Glenn L. Martin Company discussed the earth satellite program at a joint meeting of the IAS, ASME, and AIEE Branches. Mr. Walters is an Assistant Project Engineer in Structures.

He said that the vehicle is a three-stage rocket; the first two are gyro-stabilized and use a liquid propellant. The third stage is spin-stabilized and employs a solid propellant to give the satellite horizontal velocity. It will circle the earth in 90-min. periods.

Mr. Walters supplemented his talk with slides and a film on the Martin Viking, forerunner of the satellite rocket.

▶ Lieutenant Colonel V. E. Redding, Chief of the Engineering Systems Branch

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of the Air Research and Development Command, showed ARDC films at the January 9 meeting. The films depicted ARDC projects on electronic computers, crash locaters, and tests with the high-speed rocket sled. Colonel Redding commented on the projects and explained the ARDC mission.

MARVIN BAXENDALE, *Secretary*

Kent State University

A new slate of officers elected at the first January meeting were Robert Keyser, Chairman; Dan Heister, Vice-Chairman; and Norm Schehl, Treasurer. Election of the Secretary was scheduled for a later date.

▶ Members discussed the Cleveland-Akron Section meeting and tour of NACA wind tunnels on January 15.

▶ A dinner honoring graduating seniors Robert Andrews and Richard Haislet was held December 13.

ROBERT FENNING, *Secretary*

Purdue University

The final meeting of the fall semester was held on January 10. Colonel Roscoe Turner spoke on problems that confronted early aviators and told of his own experiences in barnstorming and speed races. He gave a brief history of flight beginning with the World War I Jenny and concluding with modern-day aircraft.

Officers elected for the second semester were Dave Stouppe, Chairman; Richard Pendleton, Vice-Chairman; Charles Gregory, Secretary; and Philip Atkinson, Treasurer.

WILLIAM B. LEACH, *Secretary*

San Diego State College

The Branch held a business meeting January 22 for the election of new officers. They are M. D. Chilcote, Chairman; Karl Hogguist, Vice-Chairman; James Frahm, Secretary; and James Holmes, Treasurer. Henry Chott was appointed Publications Officer. Stanford Stone, Engineering Professor at the College, was named new faculty adviser for the Branch.

Members were photographed after the meeting for a picture to appear in the school yearbook.

▶ A talk on "Testing of New Aircraft and Aircraft Instruments" was given by a Navy Fighter Air Frames Officer at the January 15 meeting. Lieutenant Commander Thatcher of the Navy Air Forces, Pacific Fleet, described steps each aircraft must undergo from the first order to final acceptance for operational duty. He said it takes about 4 years for this process to be completed.

He told of various tests employed, including flight, carrier suitability, armaments, electronic, service, and all-weather tests. Mapping of the jet stream (Project Aurora) also was discussed.

M. D. CHILCOTE, *Secretary*

Syracuse University

A panel of two men from industry, two faculty members, and two students discussed "Are We Ready When We Graduate?" at the January 9 meeting. Industry's point of view was given by James Carpenter of Carrier Corporation and Jack Graham of Porter Cable Company. Dean Watson acted as Moderator.

Each panel member spoke briefly on the subject, then the floor was opened for questions. Some 35 students and 15 faculty members took part in the discussion that followed.

▶ During Christmas vacation, 12 members toured parts of Republic Aviation Corporation's Farmingdale, N.Y., facility. Highlight of the tour was a visit to the F-84 production line. Later, a group of chief engineers from different sections outlined their duties and answered questions put to them personally by the students.

HARRY J. KIT, *Secretary-Treasurer*

Tri-State College

Members discussed rewriting Branch by-laws at the first scheduled meeting of the winter term, January 17. After the discussion, a film, *The Phantom*, was shown.

▶ Leland Cermak of Goodyear Aircraft Corporation spoke on "One Engineer's Experience in the Transition From School to Industry" at the January 3 meeting. Mr. Cermak is a Tri-State graduate, Class of 1956.

A film, *Who, Me Fly?* was shown after the talk.

▶ Carl O. Hitchcock of McDonnell Aircraft Company addressed members on "The World of Engineering—Where Will I Fit?" at a banquet on December 6.

New officers installed for the winter term were Jules Dussia, Chairman; William C. Seidel, Vice-Chairman; Eugene Prue, Secretary; Norman Mellott, Treasurer; and Nancy Poe, Student Council Representative. The IAS Scholastic Award was presented to John Parks, now of Cessna Aircraft Company.

WILLIAM C. SEIDEL, *Vice-Chairman*

University of California

Final meeting of the semester saw two films presented, *Oddities in Aircraft*, and *Crash Impact Survival in Light Planes*. The first film highlighted some unusual designs of early aircraft, most of which did not fly. The second showed results of simulated stall-spin accidents. Forces on occupants in light planes, at impact speeds of from 42-60 m.p.h., were demonstrated.

▶ A discussion on "Space Flight" was presented by Colonel Ely, an officer attached to Western Air Research and Development Command Headquarters, at the November 20 meeting. Colonel Ely explained various components of rocket craft, the possible uses for rocket-propelled space craft, advances in the field, and problems to be overcome in design and operation.

▶ The Branch sponsored an all-engineering society meeting November 13 at which Capt. N. J. Hanks spoke on "Present-Day Experimentation." Captain Hanks is a Flight Test Engineer at Edwards AFB.

He began his presentation with a film, *Air Science in Action*, describing the work of the ARDC in testing and developing aircraft equipment. Each ARDC Headquarters is concerned with different activities.

At Wright-Patterson AFB the ARDC develops new equipment and armament to meet new conditions of flight. Conditions encountered by the pilot in flight belong to medical testing, the study of pilot endurance. Other ARDC activities include geophysical studies, electronics research, missile guidance, air defense, and rescue systems.

Captain Hanks also described Edwards AFB and its facilities. These include Rogers Dry Lake, 65 miles of hard-packed sand, and a 10,000-ft. rocket sled track. He told of his own duties in the Performance Engineering Branch where aircraft undergo tests. He explained eight steps in flight test, about 200 hours of which concern performance and stability.

▶ The October 20 meeting featured a film, *We Saw It Happen*, about the history of aircraft. The development of powered flight from the Wright brothers to jet aircraft was depicted. Some 45 members and guests attended.

▶ The first meeting of the semester was held October 9. Gun-camera films of World War II fighters in action over Germany were shown.

PHYLLIS GAYLARD, *Secretary-Treasurer*

University of Kentucky

William R. Yount, Research Engineer at the University of Kentucky Aeronautical Research Laboratory, addressed the January 18 dinner meeting on "University of Kentucky Research on Aerial Camera Shutters." Mr. Yount explained the method used to evaluate shutter time on high-speed aerial cameras, using slides to illustrate his talk.

After the talk Roy D. Baldwin was elected Branch Chairman and John Schiller, Treasurer, to replace graduating officers. A discussion of participation in one of the regional student conferences concluded the meeting.

ALVIN L. WITTWER, *Secretary*

University of Washington

An address by Pete Bower, "So You Think It's New," was heard by 35 members and guests at the January 24 meeting. Mr. Bower is Flight Test Engineer at Boeing Airplane Company.

He demonstrated with slides that modern innovations in aircraft are actually old in origin and development. Swept wings, pressurized cabins, tandem landing gear, and cross-wind landing gear were shown on World War I aircraft. Counter-rotating and variable-pitch propellers appeared on 1920 aircraft. He said the innovations experienced only limited development.

Mr. Bower has one of the more complete, privately owned collections of aircraft pictures and photographs. He also owns several vintage aircraft including an Aeronca C-3 and 1912 Curtiss Pusher.

Ed Bean was appointed Treasurer during the business meeting.

LELAND M. NICOLAI, *Secretary*

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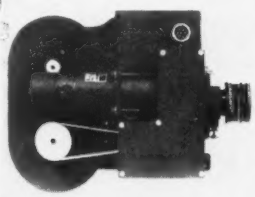

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MEMBERS ELECTED

The following applicants for membership or applicants for change of previous grades have been admitted since the publication of the list in the last issue of the Review.

Elected to Associate Fellow Grade

Quinton, Philippe P., Chief of Research, Office National d'Études et Recherches Aeronautiques.

Wagner, Herbert A., Dr. Ing., Pres. and Chief Engr., H. A. Wagner Co.

Transferred to Associate Fellow Grade

Bremer, Paul H., M.S.E., Chief Struct Engr., Lockheed Aircraft Corp. (Marietta).

Farris, Edsel S., B.S. in Ae.E., Research Engr., Boeing Airplane Co.

Height, Lewis H., Chief Proj. Engr., Lockheed Aircraft Corp. (Marietta).

Justice, Donald A., B.S. in M.E., Member, Tech. Staff, The Ramo-Wooldridge Corp.

O'Donnell, William J., Ph.D., Chief Engr., Aircraft Missile Devel., Republic Aviation Corp.

Serrell, Peter V. H., V-P and Engrg. Dir., Sandberg-Serrell Corp.

Swihart, John M., B. of Ae.E., Aero. Research Engr., NACA (Langley AFB).

Elected to MEMBER Grade

Andersen, Niels Y., B.A., Principal Physicist, Cornell Aeronautical Lab., Inc.

Asaka, Saburo, D.Sc., Prof., Ochanomizu Univ. (Tokyo).

Ballard, Richard L., M.S. in Ae.E., Staff Engr., The Glenn L. Martin Co.

Beach, William C., B. of M.E., Sect. Head, North American Aviation, Inc. (Columbus).

Bitner, John D., B.S. in Ae.E., Mgr., Design Staff, The Glenn L. Martin Co.

Carroll, Laurence B., Jr., Asst. Mgr., Fairchild Engine and Airplane Corp.

Castle, Clyde N., B. of Ind. Engrg., Mgr., Product Design Dept., The Glenn L. Martin Co.

Chaudhuri, Sudhindra N., M.S. in Math., Lecturer and Engr., Indian Institute of Science.

Chaudoin, Barney A., Jr., B.S. in Ae.E., Aerodynamics Engr., Radioplane Co.

Cord, John M., S.M., Lead Struct. Design Engr., Chance Vought Aircraft, Inc.

Corden, Carlton D., M.S. in Ae.E., Systems Group Engr., Ryan Aeronautical Co.

Dittmar, Richard B., B.A., Mgr., Proj. Devel., The Ralph M. Parsons Co.

Donaldson, Joseph C., M.S. in Math., Engr., ARO, Inc.

Duchesneau, Bernard E., B.S. in E.E., Sr. Design Engr., Boeing Airplane Co. (Wichita).

Fleming, Robert M., B.S. in Ae.E., Supvr., Dynamics Group, Minneapolis-Honeywell Regulator Co.

Guy, Russell D., Group Engr., Power Plant, Northrop Aircraft, Inc.

Haglund, Howard H., B. of M.E., Dir., Engrg., Pacific Scientific Aero-products.

Haworth, Donald R., M.S. in M.E., Sr. Propulsion Engr., Chance Vought Aircraft, Inc.

Hook, George R., B.S. in M.E., Mgr., Advanced Design Dept., The Glenn L. Martin Co.

Hopton-Jones, Fred C., B.S. in Ae.E., Struct. Group Engr., Convair Div. (Ft. Worth), General Dynamics Corp.

Houser, Bradford C., B.S. in C.E., Proj. Engr., Sandberg-Serrell Corp.

Hundere, Alf, M. of Engrg., Chairman, Aviation Dept., Southwest Research Institute.

Jarvis, John, B.S. in E.E., Chief Engr., Cadillac Gage Co.

Johnson, Charles A., B.S. in C.E., Strength Engr., McDonnell Aircraft Co.

Johnson, Edward L., Jr., B.S. in M.E., Asst. to Proj. Engr., Chance Vought Aircraft, Inc.

Kalinski, Felix A., Ph.D., V-P and Gen. Mgr., Pereira & Luckman.

Koerner, Warren G., M.S. in Ae.E., Member, Tech. Staff, The Ramo-Wooldridge Corp.

Kriebel, Anthony R., Sc.D., Mech. Engr., Stanford Research Institute.

Lenk, Eugene J., B. of Ae.E., Research Engr., Douglas Aircraft Co., Inc. (El Segundo).

Manhart, Charles D., B.S. in M.E., Asst. to V-P, Bendix Aviation Corp.

Merritt, Richard G., M.S., Research Engr., Boeing Airplane Co.

Persh, Jerome, B. of Ae.E., Asst. Div. Chief, Aerophysics Div., U.S. Naval Ordnance Lab. (White Oak).

Pote, David M., B.S. in M.E., Dept. Head, Cornell Aeronautical Lab., Inc.

Robidart, Charles M., M.S. in M.E., Proj. Mgr., National Rocket Corp.

Schmid, Alan H., B.S. in M.E., Sr. Proj. Engr., Westinghouse Electric Corp. (Kansas City).

Schmitz, Gunther K. G., Flight Test Engr., Cessna Aircraft Co.

Schneider, Robert A., Major, USAF; Service Test Pilot, 1700th Test Sq. (Kelly AFB).

Schuh, Herbert, Dr. ref. nat., Research Scientist, SAAB Aircraft Co. (Linkoping).

Siegrist, William A., B.S., Proj. Mgr., The Ralph M. Parsons Co.

Sommer, Simon C., B.S. in Ae.E., Aero. Research Engr., NACA (Moffett Field).

Speicher, Leonard J., B.S. in M.E., Sales Engr., General Electric Co. (Los Angeles).

Spreeman, Kenneth P., B.S. in Ae.E., Aero. Research Engr. (Langley Field).

Stepanoff-Dargery, George A., Sr. Design Engr., Research & Advanced Devel. Div., AVCO Manufacturing Co.

Taylor, George S., Rolls-Royce Rep., Westinghouse Electric Corp. (Kansas City).

Thomas, Herbert C., B.S., Mgr., Aircraft Flight Instrument Design, General Electric Co. (West Lynn).

Trammell, Will H., B.S. in Ae.E., Aircraft Devel. Engr., Lockheed Aircraft Corp. (Marietta).

Wade, Merwin G., B.S. in Ae.E., Research Group Engr., Convair Div. (Daingerfield), General Dynamics Corp.

Waidelich, Jack P., B.S., Engr., Aerojet-General Corp.

Waldeck, George H., Supvr., Drafting, Curtiss-Wright Corp.

Williams, Benjamin H., M.S. in Ae.E., Aerodynamicist, Hughes Aircraft Co.

Willis, Conrad M., B.S. in M.E., Mech. Engr., NACA (Langley Field).

Winnard, Walter H., Jr., B. of M.E., District Mgr., Aerojet-General Corp.

Wiser, George L., Chief Engr., The Sierracin Corp.

Transferred to MEMBER Grade

Ashby, George C., Jr., M.S. in Ae.E., Aero. Research Scientist, NACA (Langley Field).

Bellows, Harry A., Jr., B.S. in Ae.E., Stress Analyst "A," Douglas Aircraft Co. (Santa Monica).

Blakeslee, Donald J., B.S. in Ae.E., Assoc. Engr., The RAND Corp.

Gibson, Paul A., Flight Test Engr., CAA (Los Angeles).

Hopkins, Harold B., Jr., B. of Ae.E., Research Aerodynamicist, Grumman Aircraft Engineering Corp.

Hoyler, Wilburne F., M.S. in M.E., Design Group Engr., Convair Div. (Ft. Worth), General Dynamics Corp.

Jackson, Eugene B., M.A., Librarian, Research Staff, General Motors Corp.

McCormick, Jack E., Sales Engr., Boeing Airplane Co.

Peters, Glenn M., B.S. in Ae.E., Aerodynamicist, H. L. Yoh Co.

Propper, Edouard M., M.S. in Ae.E., Sr. Struct. Engr., Convair Div. (Ft. Worth), General Dynamics Corp.

Radhakrishnan, Spinivasa, S.M. in Ae.E., Chief of Struct., Hindustan Aircraft, Ltd.

Riley, James L., B.S. in Ae.E., Proj. Engr., WADC (Wright-Patterson AFB).

Siegfried, William H., B. of Ae.E., Assoc. Engr., Aerodynamics Group, Douglas Aircraft Co., Inc. (Santa Monica).

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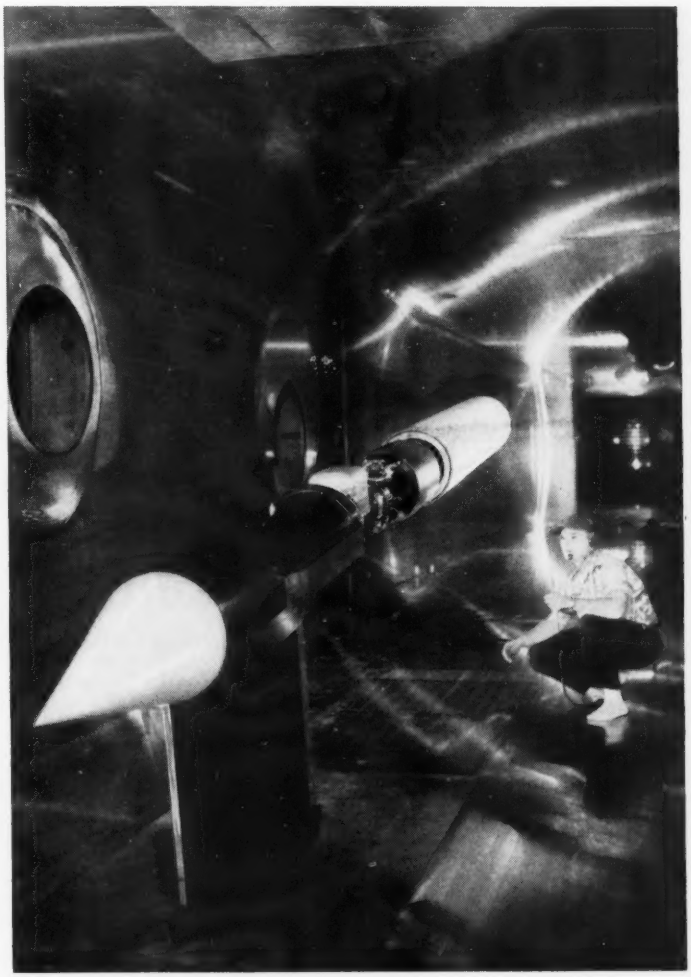

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Winnett, Alpha G., Jr., Sr. Weight Engr., North American Aviation, Inc. (Columbus).

Winter, Ralph O., M.S. in Appl. Mech., Stress Engr., The Emerson Electric Manufacturing Co.

Elected to Associate Grade

Bowlus, Glenn H., General Engr., Naval Ord. Test Station (Pasadena).

Butler, James C., B.S., Service Engr., Metal Parts and Equipment Co.

Carter, Stephen K., B.S. in M.E., Assoc. Engr., The Glenn L. Martin Co.

Griswold, James E., B.S. in Ae.E., Engr., Cessna Aircraft Co.

Hinchey, James R., Aerodynamicist, College of A & MA (New Mexico).

Hinman, Thomas T., Military Sales Mgr., Lockheed Aircraft Service, Inc.

Hixson, Roy, B.S. in C.E., Stress Engr., The Glenn L. Martin Co.

Kamholtz, Stanley, Liaison Engr., Convair Div. (San Diego), General Dynamics Corp.

Kotva, Ralph M., Production Process Engr., Ford Motor Co. (Chicago).

McLeod, Homer H., Reliability Inspector, North American Aviation, Inc. (Downey).

McMaster, Joseph R., Jr., Sales Engr., Joy Manufacturing Co.

Moore, Leon M., Design Engr., Convair Div. (San Diego), General Dynamics Corp.

Perkins, Arthur W., Assoc. Editor, *Aeronautical Purchasing Magazine*, Industrial Publishing Corp.

Poesch, William L., B.S., Design Engr., Hughes Aircraft Co.

Shenk, Leo H., Research Engr., Los Angeles Ord. District, Dept. of the Army.

Smith, Darrell E., B.S. in M.E., Assoc. Engr. "A," Aerodynamics Group, Douglas Aircraft Co., Inc. (Tulsa).

Ulrich, John J., B.S., Operations Analyst, General Electric Co. (Cincinnati).

Yeager, Richard A., B.S. in E.E., Aero. Research Engr., Lewis Flight Propulsion Lab., NACA (Cleveland).

Young, James K., B.S. in M.E., Member, Tech. Staff, Hughes Aircraft Co.

Zeiner, Hugh N., B.S. in M.E., Engr., McDonnell Aircraft Corp.

Transferred to Associate Grade

Ahrens, Robert E., B.S., Service Engrg. Rep., Douglas Aircraft Co., Inc. (El Segundo).

Arredondo, Charles A., B. of Ae.E., 2nd Lt., USAF; Proj. Engr., Air Force Special Weapons Command (Kirtland AFB).

Bailey, John B., M.S. in Ae.E., Lt., USN; Aviator.

Barton, Robert A., B. of Ae.E., Assoc. Engr., Lockheed Aircraft Corp. (Marietta).

Bertolino, Francis L., Design Engr., North American Aviation, Inc. (Downey).

Blake, Bruce B., B.S. in Ae.E., Graduate Student, Massachusetts Institute of Technology.

Bonnar, David K., B. of Ae.E., Assoc. Engr., Douglas Aircraft Co., Inc. (Santa Monica).

Brook, John W., B. of Ae.E., Research Engr., Grumman Aircraft Engineering Corp.

Cossette, Charles H., M.S. in Ae.E., Aerodynamic Engr., North American Aviation, Inc. (Columbus).

Curry, Alva L., Jr., B.S. in Ae.E., Ens., USN; Student Aviator (Pensacola).

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Doyel, Arthur T., Jr., Design Engr., Autonetics Div., North American Aviation, Inc. (Downey).

Duliakas, Chris J., B.S. in Ae.E., Engr., Hughes Aircraft Co.

Falco, Michael, B.S. in Ae.E., Research Engr., Grumman Aircraft Engineering Corp.

Freeman, Thorp L., B. of Ae.E., 2nd Lt., USAF; Student, New York Univ.

Furrer, John W., B.S. in Ae.E., 2nd Lt., U.S. Army; Company Exec. Officer (Ft. Belvoir).

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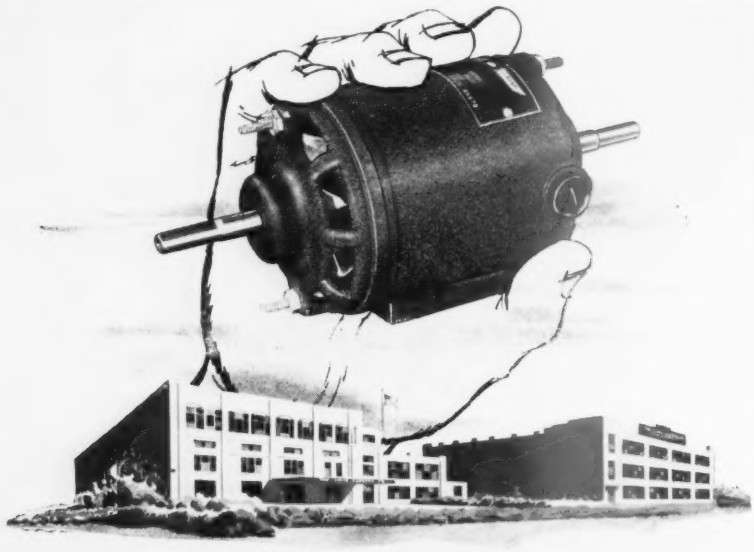

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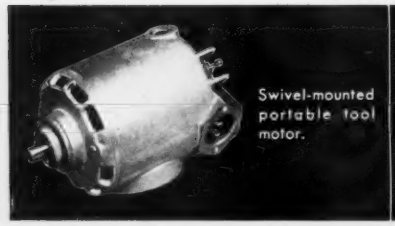

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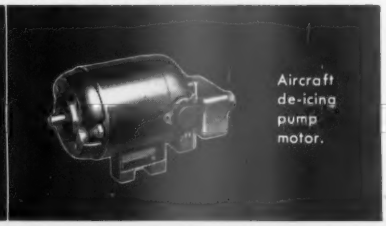

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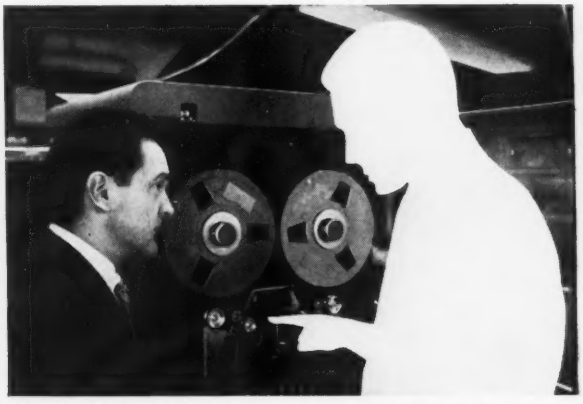

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Acoustics, Sound, & Noise

Excitation of Resonance by Air Flow. D. I. Blokhintsev. *U.S., Navy Dept., David W. Taylor Model Basin, Transl. 270,* Jan., 1957. 11 pp. Investigation of the excitation of sound by an air stream blowing over the mouth of a resonator. It is shown that this excitation can be regarded as the result of resonance between the oscillations of a system of vortices which are shed at the edges of the resonator and the natural oscillations of the resonator.

The Intensity of Aeolian Tones. O. M. Phillips. *J. Fluid Mech.*, Dec., 1956, pp. 607–624. 11 refs. Calculation of the intensity of radiated sound expressed in terms of the fluctuations in force upon a moving rigid body. The fluctuations in lift and drag upon a circular cylinder at Reynolds Numbers between 40 and 160 are determined by integrating the fluctuations in momentum in the eddying wake, using Kovasznay's experimental data.

The Scream of a Jet in a Six-Inch Test Cell. R. H. Jacobson. *Tele-Tech*, Feb., 1957, pp. 63–65, 112. Description of the Armour Research Foundation's high-intensity sound chamber in terms of its operating principle, construction, signal source, pressure measurements, instrumentation, calibration, and determination of resonance effects. Includes discussion of jet noise.

Dämpfung des Strahllärms. R. W. Schulz. *Luftfahrttechnik*, Dec. 15, 1956, pp. 229, 230. In German. Study of the problem of jet noise suppression.

Aerodynamics

Analysis and Design of Air Motors. Otmar E. Teichmann. *Prod. Eng.*, Feb., 1957, pp. 167–178. Study of flow through vane air motors in which pressure drops, torque losses, and compression and expansion efficiencies are derived in explicit form. Graphs are plotted to permit easy design analysis of new and existing motors and the quick determination of the effect of changing the various motor parameters.

Aerothermodynamics

On Rayleigh's Problem for a General Cylinder. J. C. Cooke. *J. Phys. Soc. Japan*, Nov., 1956, pp. 1,181–1,184. Extension of Hasimoto's solution of the Rayleigh problem to determine the velocity distribution at any point in the fluid. Five terms of the series are given, and the skin friction is evaluated.

Boundary Layer

Some Aspects of Unsteady Laminar Boundary Layer Flows. Sin-I Cheng. (*Princeton U., Dept. Aero. Eng. Rep. 311*, July 1, 1955.) *Quart. Appl. Math.*, Jan., 1957, pp. 337–352. Abridged. OSR-supported research.

Experimental Investigation on the Transition of Laminar Separated Layer. Hiroshi Sato. *J. Phys. Soc. Japan*, June, 1956, pp. 702–709. Results of a hot-wire anemometer survey of velocity fluctuation showing the existence of a sinusoidal wave, the frequency of which lies in the unstable zone predicted by the stability theory.

Free Convection Past a Vertical Plate. Morton Finston. *ZAMP*, Nov. 25, 1956, pp. 527–529. Derivation of the ordinary differential equations involved in obtaining exact solutions for a family of plate temperature variations.

Control Surfaces

Blown Flaps by Supermarine. *The Aeroplane*, Jan. 18, 1957, pp. 86, 87. Explanation and examination of the blown flap in terms of the performance benefits obtained on the Supermarine N.113 naval strike fighter.

Low Speed Wind Tunnel Tests on Perforated Square Flat Plates Normal to the Airstream; Drag and Velocity Fluctuation Measurements. B. G. de Bray. *Gt. Brit., RAE TN Aero.2475*, Oct., 1956. 13 pp.

Fluid Mechanics & Aerodynamic Theory

Determining Drop Size Distribu ion of a Nozzle Spray. W. E. Ranz and Clarence Hofelt, J^r. *Ind. & Eng. Chem.*, Feb., 1957, pp. 288–293. Development of a test method using the principle of inertial impaction in a special flow system to give a relative numerical measure to size distribution.

A Sphere Theorem on the Stokes Equation for Axisymmetric Viscous Flow. Hidenori Hasimoto. *J. Phys. Soc. Japan*, July, 1956, pp. 793–797.

The Flow Due to Impulsive Motion of a Wedge. II. Akira Sakurai. *J. Phys. Soc. Japan*, Sept., 1956, pp. 987–993. Analysis of transient flow around a receding wedge with rarefaction waves. Two limiting cases of small, almost blunt vertex angles are discussed.

A Study of the Compressible Flow Past Tomotika-Tamada's Profiles. Hideo Takami. *J. Phys. Soc. Japan*, Apr., 1956, pp. 446–451. 14 refs. Application of approximate theoretical methods to the study of two-dimensional, high-subsonic adiabatic gas flows. Methods for calculating the velocity distributions over the profiles include the von Kármán-Tsien, the W. K. B., the M^2-expansion, and the Meksyn-Imai procedures, and their results are compared with the Tomotika-Tamada exact solutions and with Naruse's results obtained by means of the thin-wing-expansion method.

A Study of the Compressible Flow Past a Cherry Profile. Hideo Takami. *J. Phys. Soc. Japan*, Feb., 1956, pp. 145–154. 17 refs. Analysis of the compressible flow phenomena using the von Kármán-Tsien, the M^2-expansion, and the Meksyn-Imai methods.

Experimental Investigation of the Wake Behind a Sphere at Low Reynolds Numbers. Sadatoshi Taneda. *J. Phys. Soc. Japan*, Oct., 1956, pp. 1,104–1,108.

Experimental Investigation of the Wakes Behind Cylinders and Plates at Low Reynolds Numbers. Sadatoshi Taneda. *J. Phys. Soc. Japan*, Mar., 1956, pp. 302–307. 10 refs. Tests using photographic techniques to determine the critical Reynolds Number at which twin vortices appear in the rear of a circular cylinder, to detect the commencement of wake oscillation in the same area, and to examine the wake behind a flat plate parallel to the direction of motion. Includes the description and use of a new experimental method to obtain detailed knowledge about the structure and nature of the von Kármán vortex street.

Studies on Wake Vortices. III—Experimental Investigation of the Wake Behind a Sphere at Low Reynolds Numbers. Sadatoshi Taneda. *Kyushu U., Rep. Res. Inst. Appl. Mech.*, Oct., 1956, pp. 99–105.

Experimental Studies of Supersonic Flow Past a Circular Cylinder. Kim Chul-Soo. *J. Phys. Soc. Japan*, Apr., 1956, pp. 439–445. 10 refs. Mach-Zehnder interferometer and schlieren measurements for the mixed-type flow around a circular cylinder placed normal to the general flow at Mach Numbers ranging from 1.35 to 6.0. Parameters measured include the shape of the detached shock wave, the distance of the shock wave from the cylinder nose, the pressure coefficient on the surface of the cylinder, the density distribution behind the detached shock, and the streamlines in the subsonic region.

Note on the Drag on a Circular Cylinder Moving with Low Speeds in a Semi-Infinite Viscous Liquid Bounded by a Plane Wall. Yorisaburo Takaisi. *J. Phys. Soc. Japan*, Sept., 1956, pp. 1,004–1,008.

The Drag on a Circular Cylinder Placed in a Stream of Viscous Liquid Midway Between Two Parallel Planes. Yorisaburo Takaisi. *J. Phys. Soc. Japan*, Oct., 1956, pp. 1,092–1,095.

Soprotivlenie Klinovidnogo Profilia, Obtekaemogo Potokom Zvukhovoi Skorosti. S. K. Aslanov. *Prikl. Mat. i Mekh.*, 1956, pp. 756–760. 13 refs. In Russian. Study of the drag of wedge-shaped profiles in sonic flow.

On the Hypersonic Viscous Flow Past Slender Bodies of Revolution. Michiru Yasuhara. *J. Phys. Soc. Japan*, Aug., 1956, pp. 878–886. 10 refs. Development of a similarity solution for the special case when the radial coordinate of the body surface at section x is proportional to $x^{3/4}$.

The Magnus Force on Spinning Cylinders. Ray W. Van Aken and Howard R. Kelly. *IAS 25th Annual Meeting, New York, Jan. 28–31, 1957, Preprint 712.* 15 pp. 32 refs. Members, $0.50; nonmembers, $0.85. Review of experiments on Magnus effect which have shown a pattern in the behavior of Magnus force with different Reynolds Numbers.

On the Viscous Shear Flow Around a Circular Cylinder. II—Oseen's Approximation. Mitutosi Kawaguti. *J. Phys. Soc. Japan*, May, 1956, pp. 570–583.

The Forces Acting on Two Equal Circular Cylinders Placed in a Uniform Stream at Low Values of Reynolds Number. Hiroomi Fujikawa. *J. Phys. Soc. Japan*, May, 1956, pp. 558–569.

The Forces Acting on Two Circular Cylinders of Arbitrary Radii Placed in a Uniform Stream at Low Values of Reynolds Number. Hiroomi Fujikawa. *J. Phys. Soc. Japan*, June, 1956, pp. 690–701.

The Flow Past a Flat Plate Accompanied with an Unsymmetric Dead Air at Mach Number 1. Takeo Sakurai. *J. Phys. Soc. Japan*, June, 1956, pp. 710–715. 10 refs.

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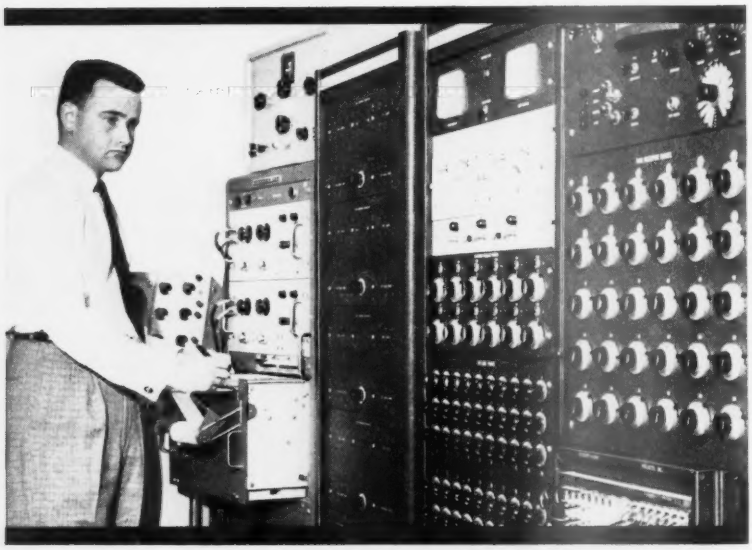

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On Supersonic Flow Behind a Curved Shock. R. E. Meyer. *Quart. Appl. Math.*, Jan., 1957, pp. 433–436. Derivation of a solution which accounts, to a first approximation, for the entropy gradients and vorticity downstream of the shock attached to the nose of a sharp-edged cylindrical body immersed in a uniform supersonic stream.

Reflection of Shock Waves. I—Pseudo-Stationary Case. Ryuma Kawamura and Haruo Saito. *J. Phys. Soc. Japan*, May, 1956, pp. 584–592. Theoretical and shock-tube investigation of shock reflection at a fixed wall. Includes analysis of the flow characteristics in Mach-reflection cases.

Interaction of Nonuniform Shock Waves. W. E. Drummond. *J. Appl. Phys.*, Jan., 1957, pp. 76–85. Analysis of the basic interactions of shock waves in one-dimensional unsteady and two-dimensional steady flows. Method involves the mapping of a hodograph plane, neglecting the effects of third and higher orders in shock strength. The resulting equations are linear and can be solved by straightforward numerical method.

Internal Flow

Short Methods for Calculating Fluid Flow. Dale Kelly. *Instruments & Automation*, Jan., 1957, pp. 74–77. Method for calculating fluid flow from the pressure differential developed by a venturi, nozzle, sharp-edged orifice, or pitot tube. Charts giving flow factors for air and motor are presented.

The Flow of Gas Through Composite Systems at Very Low Pressures. C. W. Oatley. *Brit. J. Appl. Phys.*, Jan., 1957, pp. 15–19. Theoretical investigation to derive an improved method of calculation which obviates the assumption—shown to be untenable—required in the conventional method and the incorrect results thus obtained, and achieves a high degree of accuracy. The physical basis for the new procedure and its application to various practical problems are discussed.

Die Nusseltsche Zahl für laminare Strömung im zylindrischen Rohr mit konstanter Wandtemperatur. Sergej Pahor and Janez Strnad. *ZAMP*, Nov. 25, 1956, pp. 536–538. In German. Determination of the Nusselt modulus for laminar flow through a pipe with constant wall temperature as a function of the Peclet modulus. This function is represented by a diagram.

Supersonic Jet with the Ambient Pressure Corresponding to Its Constant Pressure Point. Hakuro Oguchi. *J. Phys. Soc. Japan*, Feb., 1956, pp. 155–159. Investigation using the hodograph method, under the transonic approximation for a plane jet issuing from a parallel supersonic nozzle into a chamber where the pressure corresponds to the constant pressure point on the shock polar.

Stability & Control

Longitudinal Stability. F. J. Fitzgerald. *Lockheed Field Serv. Dig.*, Jan.-Feb., 1957, pp. 1–9. Discussion of pitch oscillation and of the changes in elevator booster mechanisms and inspection procedures to prevent this disturbance in Super Constellations.

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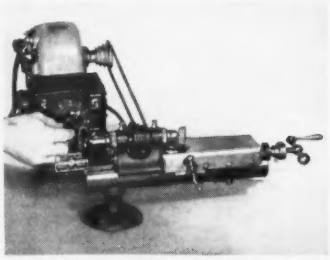

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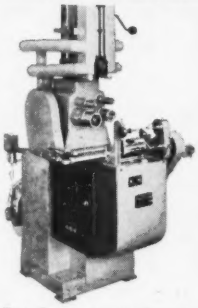

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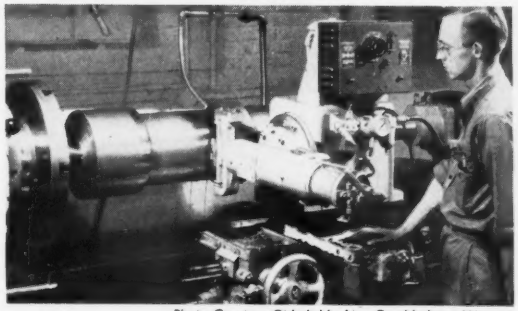

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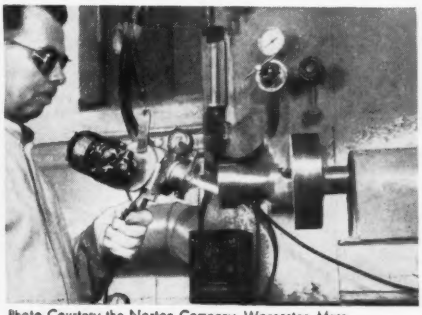

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Cross Coupling Dynamics and the Problems of Automatic Control in Rapid Rolls. J. D. Welch and R. E. Wilson. *IAS 25th Annual Meeting, New York, Jan. 28–31, 1957, Preprint 691.* 23 pp. Members, $0.65; nonmembers, $1.00. Physical interpretation of the major factors involved in the cross-coupling phenomena and consideration of automatic control as a means of alleviating the adverse effects of such phenomena.

Wings & Airfoils

Application of Imai's Transonic Approximation Method to the Compressible Flow Past a Kaplan Bump. Yaso'o Matunobu. *J. Phys. Soc. Japan*, Apr., 1956. pp. 452–457.

Laminarprofil-Messungen des NACA. Walter Stender. *Luftfahrttechnik*, Dec. 15, 1956, pp. 218–227. 12 refs. In German. Theoretical and experimental data on a number of NACA laminar airfoil profiles.

Zakon Ploskikh Sechenii v Aerodinamike Bol'shikh Sverkhzvukovych Skorostei. A. A. Il'iushin. *Prikl. Mat. i Mekh.*, 1956, pp. 733–755. In Russian. Includes reformulation of the problem of supersonic aerodynamics, linearized theory of lifting surfaces, and application to the cases of rotating cylinders, shells, and wedge-shaped bodies.

On the Kernel Function of the Integral Equation Relating the Lift and Downwash Distributions of Oscillating Finite Wings in Subsonic Flow. Appendix A—**Derivation of the Integral Equation that Relates the Downwash and Lift for a Finite Wing Based on Reference 21.** Appendix B—**Reduction of the Kernel Function for Three-Dimensional Flow to That for Two-Dimensional Flow.** Appendix C—**Some Remarks of Evaluation of the Kernel Function.** Appendix D—**Alternate Form of Equation (20).** Charles E. Watkins, Harry L. Runyan, and Donald S. Woolston. *U.S. NACA Rep. 1234*, 1955. 16 pp. 30 refs. Supt. of Doc., Wash., $0.25.

Aeroelasticity

The Flutter Properties of a Simple Aero-Isoclinic Wing System. N. C. Lambourne and A. Chinneck. *Gt. Brit., ARC R & M 2869* (Jan., 1950), 1956. 16 pp. BIS, New York, $0.81.

On the Transverse Vibration of an Elliptic Plate with Clamped Edge. Yoshio Shibaoka. *J. Phys. Soc. Japan*, July, 1956, pp. 797–803. Derivation of an exact solution by means of Mathieu and modified-Mathieu functions. Includes a graphic description of, and an approximate formula for, the relationship between the frequency of the fundamental mode of vibration and the eccentricity of the elliptic plate.

Vibration Frequency Charts. J. N. Macduff and R. P. Felgar. (*ASME Annual Meeting, New York, Nov., 1956, Paper.*) *Mach. Des.*, Feb. 7, 1957, pp. 109–115. Application of tables and nomographs to the estimation of natural frequencies of uniform and nonuniform beams and uniform plates.

Aeronautics, General

Research, Development and Technical Issues. II, III. Arnold Hall. *Flight*, Jan. 4, 11, 1957, pp. 19–22; 51–54.

The Importance of Time in Aircraft Manufacture. F. R. Banks. *J. RAeS*, Jan., 1957, pp. 5–25; Discussion, pp. 25–36. Discussion of lead time in the British aircraft industry, in comparison with the American industry. Recommendations are made for planning procedures to help reduce this time.

Air Transportation

Future Technical Trends in Air Transportation. G. F. Worley. (*IAS Annual Natl. Meeting, San Diego, Aug. 15–17, 1956, Paper.*) *Esso Air World*, Nov.-Dec., 1956, pp. 62–67.

Beitrag zum Problem der schnellsten Flugverbindung zwischen zwei Punkten. Ernst Adams. *ZFW*, Jan., 1957, pp. 12–15. 13 refs. In German. Graphical method for determining cruising speed at constant height for the shortest flight duration between two arbitrary points at any distribution of wind.

A New Approach to Operating Costs. F. W. Free. *The Aeroplane*, Jan. 25, 1957, pp. 108, 109. Developmental discussion and outline of the features of a method for comparing the practical economic capabilities of different transport aircraft by including the potential annual revenue-earning capacity as a major consideration in such comparisons.

A Manufacturer's Philosophy of Meeting Today's Business Air Transport Requirements. Dwane L. Wallace. *SAE Annual Meeting, Detroit, Jan. 14–18, 1957, Preprint 55.* 10 pp.

Airplane Design

Aeronautics in 1956. I, II. *The Engr.*, Jan. 4, 11, 1957, pp. 16–19; 53, 54. Review of design trends for supersonic aircraft and discussion of the performance and capabilities of the new jet air liners.

CL-28; Some Notes on the Largest Aeroplane Yet Built in Canada. *Flight*, Jan. 25, 1957, pp. 105, 106.

O "Tupolev TU-104." *Aviação*, Nov., 1956, pp. 11, 15. In Portuguese. Description of the Russian jet transport, Tupolev TU-104, giving interior layout, radio equipment, and estimated performance.

S.N.C.A.N. Nord 2501 Noratlas. *Luftfahrttechnik*, Dec. 15, 1956, pp. 232–235. In German. Design and description of the French military transport Nord 2501 "Noratlas."

Ein sowjetisches Schlachtflugzeug mit Turboantrieb als Nachfolger des Erdkampfflugzeuges, IL-10. *Flugwelt*, Jan., 1957, p. 35–37. In German. Description of the Soviet ground-attack aircraft developed from the Strafing Plane IL-10.

Freightliner. *Flight*, Jan. 18, 1957, pp. 66, 67. (Also in *The Aeroplane*, Jan. 18, 1957, p. 77.) Design characteristics and estimated performance of a twin-boom projected Armstrong-Whitworth transport.

Many Factors Determine Airfreighter Design. R. F. Stoessel and E. W. Fuller. *Av. Age*, Feb., 1957, pp. 64–71 ff. Presentation of some design parameters to be used for commercial air freighters.

SO-9050 Trident II, ein europäischer Interceptor. *Flugwelt*, Jan., 1957, pp. 27, 28. In German. Design and description of the SO-9050 Trident II, a European interceptor.

The Convair B-58 "Hustler" Multiple Weapons System. *Interavia*, Jan., 1957, pp. 33–36. Discussion of developmental problems and design characteristics of a supersonic bomber.

The Structure of the Comet. (*de Havilland Gazette*, Aug., 1956, pp. 121–124.) *Aero Res. TN Bul. 165*, Sept., 1956, pp. 1–4.

Pilot's View of The Transport Plane. R. F. Adickes. *Air Line Pilot*, Jan., 1957, pp. 2–4, 21, 22. Discussion of air-liner safety requirements in terms of visibility, controls, instrument arrangement, switch and lever arrangement, fire emergency procedures, performance, and functional reliability.

Supersonic Passenger-Carrying Aircraft. B. S. Shenstone. *Can. Aero. J.*, Jan., 1957, pp. 13–16. Discussion of the economic and acoustic problems to be encountered, and description of the possible requirements for a Mach 1.15 air liner in terms of its capacity, frequency, shape, power, and weight.

Air Weapons Systems Analysis. Norman Precoda. *Operations Res.*, Dec., 1956, pp. 684–698. 26 refs. Method for determining design objectives most likely to optimize systems performance for a strategic-type bomber.

The Development of Business Transport Aircraft. Winfield H. Arata, Jr. *SAE Annual Meeting, Detroit, Jan. 14–18, 1957, Preprint 56.* 22 pp. 19 refs. Discussion of the design for a jet-propelled executive transport. Includes market analysis, configuration and power-plant selection, interior arrangements, operating procedures, and economics.

Air Conditioning & Pressurization

Druck- und Klimaanlagen in neuzeitlichen Verkehrsflugzeugen. Arno Fischer. *Luftfahrttechnik*, Jan. 15, 1957, pp. 12–20. In German. Design and description of air-conditioning and pressurization systems of transport aircraft.

Cockpits

The Pilot's Place; A Consideration of Cockpits, Then, Now and Tomorrow. L. F. E. Coombs. *Flight*, Jan. 25, 1957, pp. 101–104.

Fuel Tanks

Razor-Thin F8U Wing Still Carries Fuel. H. A. Helstrom, Jr., and R. C. Breckur. *Av. Age*, Feb., 1957, pp. 26, 27. Discussion of problems in the construction of integral fuel tanks, using the injection sealing method combined with close tolerances.

Landing Gear

Avtomaticheskoe Tormozhenie Koles Reaktivnogo Samoleta. T. Bashta. *Grazhdanskaia Aviatsiia*, Nov., 1956, pp. 18–21. In Russian. Evaluation of auto-

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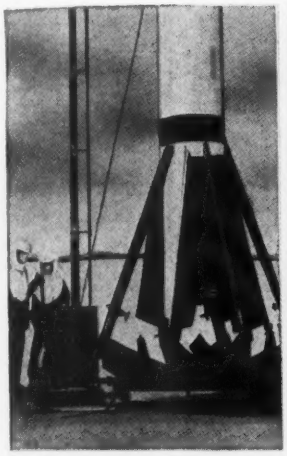

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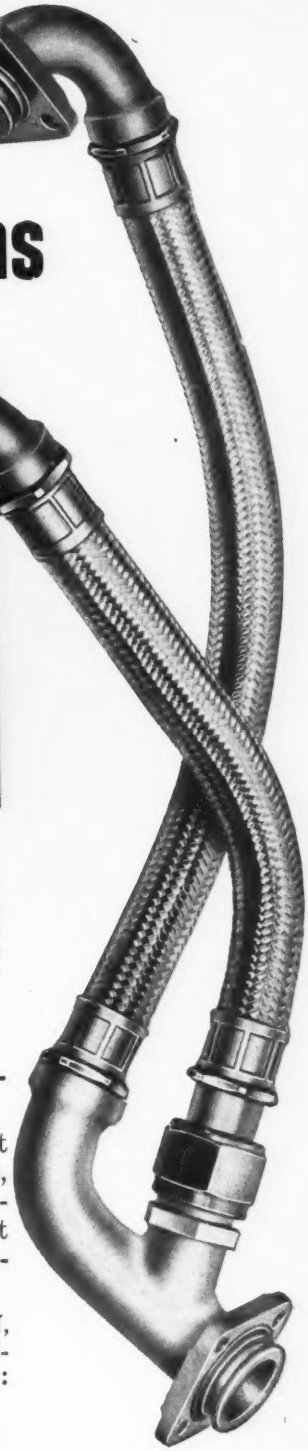

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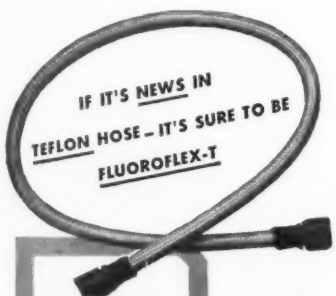

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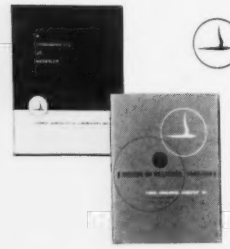

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Cycling Hydraulic System Eliminates Positioning Errors. *Des. News*, Jan. 15, 1957, pp. 22, 23.

Operation & Performance

Operational Angles on the B-47. Richard E. Evans. *Flight*, Jan. 25, 1957, pp. 115–118.

Long Range DC-8 is OK for Shorter Ranges Too. Richard S. Shevell. (*SAE Natl. Aero. Meeting, New York, Apr., 1956, Paper.*) *SAE J.*, Jan., 1957, pp. 27–30. Abridged. Discussion of the advantages of the aircraft in terms of reduced fuel consumption, flexibility with regard to altitude and ambient temperature, and performance after engine failure.

Wing Group

Design and Testing Give Britannia Good Fatigue Life. Irwin Stambler. *Av. Age*, Feb., 1957, pp. 30–35 ff.

Airports

Design of Consoles and Voice Communication Systems for Aerodrome Control Towers. K. K. Neely, R. E. F. Lewis, and W. D. MacNamara. *Can. Aero. J.*, Jan., 1957, pp. 17–20.

Hydrant Fueling. R. H. Barrett. *SAE Annual Meeting, Detroit, Jan. 14–18, 1957, Preprint 61.* 14 pp. Description of the layout for a hydrant fueling system based on equipment in operation at the San Francisco International Airport.

Planning for Handling Jet Transports at the Passenger Terminal. H. O. Olson. *SAE Annual Meeting, Detroit, Jan. 14–18, 1957, Preprint 60.* 8 pp. Discussion of permanently fixed handling facilities necessary for ramp servicing of transports. These facilities include fueling, electrical power, air conditioning, pneumatic power, and baggage handling.

Aviation Medicine

Aero Medical Investigation of Aircraft Accidents. H. G. Moseley. *IAS 25th Annual Meeting, New York, Jan. 28–31, 1957, Preprint 672.* 9 pp. Members, $0.35; nonmembers, $0.75. Discussion outlining some of the human causes of, and injuries resulting from, airplane accidents and showing how these can be determined, evaluated, and sometimes prevented by thorough aeromedical inquiry.

The Role of the Pathologist in Aircraft Accident Investigations. F. M. Townsend, V. A. Stembridge, and F. K. Mostofi. *IAS 25th Annual Meeting, New York, Jan. 28–31, 1957, Preprint 673.* 11 pp. Members, $0.35; nonmembers $0.75. Discussion of the necessity for pathological examination in fatal aircraft accidents to help determine the causes. The organization of a systematic approach to the problem, and the classification of results are also discussed.

Experimental Material Flown on Aero Medical Field Laboratory Balloon Flights 46 Through 71. C. H. Steinmetz. *USAF HADC TN 56-2[AD 113031]*, 1956, 17 pp. Description of biological and physical tests on mammalian and nonmam-

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Personal Experiences During Short Periods of Weightlessness Reported by Sixteen Subjects. S. J. Gerathewohl. *Astronautica Acta*, Fasc. 4, 1956, pp. 203–217. 24 refs. Discussion of a series of experiments on weightlessness conducted with a Lockheed T-33 for dives and parabola flights yielding practical weightlessness from 10 to 30 sec. duration.

Computers

An Accumulator Unit for a Dekatron Calculator. R. Townsend and K. Camm. *Electronic Eng.*, Feb., 1957, pp. 58–64. Description of a calculator which uses cold-cathode trigger tubes and Dekatrons as its main elements, operates in a parallel mode, and takes its input from punched cards. In the unit decimal numbers may be added or subtracted, the sum being returned to the main store and multiplied or divided by ten or unity.

A Multi-Channel Analyser Using a Rectifier Matrix for Channel Selection. P. K. Patwardhan. *J. Sci. & Ind. Res., Sect. A*, Oct., 1956, pp. 439–443. Description of an analyzer utilizing 5,687 high-current capacity valves as buffer amplifiers to furnish a high ratio of selected to nonselected signals.

Ein Elektronenvervielfacher als Puls-lichterzeuger. Reinhold Gerharz. *ZAMP*, Nov. 25, 1956, pp. 529–536. 14 refs. Description of a 7-stage electron multiplier with grid-control system.

Méthode de Résolution Autocommandée sur Calculateur Électronique Arithmétique. Liliane Gaudfernau. *La Recherche Aéronautique*, Nov.-Dec., 1956, pp. 31–38. In French. Development of a technique of numerical calculation, using an electronic computer.

The "White" Light Response of Four Semiconductor Photoelectric Cells. A. K. Walton. *Gt. Brit., RAE TN M.S.28*, June, 1956. 20 pp. Analysis of the problem of detecting small photoelectric signals in the presence of large and variable dark currents for which the use of a modulated light source is suggested.

Education & Training

The Challenge to America's Leadership in Technology. Edward H. Wynn. *IAS 25th Annual Meeting, New York, Jan. 28–31, 1957, Preprint 707.* 16 pp. Members, $0.50; nonmembers, $0.85. Survey of the technical educational systems in the United States and Russia comparing the educational support received by the aircraft industries and air forces of the two nations.

Tools for Management (A Symposium). *IAS 25th Annual Meeting, New York, Jan. 28–31, 1957, Preprint 721.* 19 pp. Members, $0.35; nonmembers, $0.75. Contents: The Purpose of Engineering Management, Edward C. Wells. The Symbiosis of Universities and Industry, A. A. Fejer. The Consulting Psychologist and Engineering Management, Theodore T. McKnelly. Management Tools for Product Development, R. C. Sebold.

Electronics

Component Developments Influencing Aviation Electronics. Luther Davis, Jr., and Lawrence G. Rubin. *IAS 25th Annual Meeting, New York, Jan. 28–31, 1957, Preprint 679.* 11 pp. Members, $0.35; nonmembers, $0.75. Survey of electronic materials and techniques for high-speed aircraft in terms of reliability, weight, and low power consumption.

Formation of High-Density Electron Beams. George R. Brewer. *J. Appl. Phys.*, Jan., 1957, pp. 7–15. 16 refs. Discussion of the physical principles underlying the design and performance of electron guns suitable for the generation of high density electron beams.

The Sound-Level Meter as an Audio-Frequency Voltmeter and Amplifier. E. E. Gross. *Gen. Radio Exp.*, Jan., 1957, pp. 3–7. Description of an instrument used as a small detector, as a gain-loss and noise-hum measuring device, and as a monitoring and recording instrument.

Amplifiers

K Teorii Nelineinykh Reshaiushchikh Elementov, Ispol'zuiushchikh Kusochno-Lineinuiu Approksimatsiiu. B. Ia. Kogan. *Avtomatika i Telemekhanika*, Dec., 1956, pp. 1,081–1,091. In Russian. Derivation of fundamental relationships for the operational amplifier with nonlinear conductivities approximated stepwise. Some methods of the synthesis of function generators built on diodes are considered from the standpoint of minimization of the current characteristic steepness.

Antennas

Antenna System Problems with High Speed Aircraft. F. W. Bushman. *IAS 25th Annual Meetings, New York, Jan. 28–31, 1957, Preprint 669.* 7 pp. Members, $0.35; nonmembers, $0.75. Discussion of design and installation problems for high-frequency and super-high-frequency band antennas.

The Image Method of Beam Shaping. Paul T. Hutchison. *IRE Trans., AP Ser.*, Oct., 1956, pp. 604–609. Description of the image scheme of beam shaping which employs a section of a parabolic reflector fed by an electromagnetic horn and of an image of the horn provided by a flat conducting ground plane below the axis of the reflector.

The Radiating Properties of End-Fire Aerials. Appendix—**The Radiation of a Pattern Dielectric Rod Aerial.** J. Brown and J. O. Spector. *(IEE Paper 2216 R.) Proc. IEE, Part B*, Jan., 1957, pp. 27–34. 20 refs. Development of a new theory based on the concept that the function of the guiding structure in an end-fire aerial is to distribute the energy supplied to the aerial over a radiating aperture. Detailed comparisons are made of the Yagi and dielectric-rod type of aerials. Includes comparison of theoretical and experimental results.

Radiation by Disks and Conical Structures. A. Leitner and C. P. Wells. *IRE Trans., AP Ser.*, Oct., 1956, pp. 637–640. Army-sponsored application of the Lebedev integral transform to a class of boundary-value problems in the theory of diffraction and antennas.

A High-Performance Conically-Scanning X-Band Antenna of Novel Design. J. G. McCann and R. J. Stegen. *IRE Trans., AP Ser.*, Oct., 1956, pp. 628–631. Description of a conically scanning antenna which consists of a scanner mechanism, rear feed, and 8-ft. diam. paraboloid producing a pencil beam having equal E- and H-plane beamwidths.

Loop Antenna Measurements. Phyllis A. Kennedy. *IRE Trans., AP Ser.*, Oct., 1956, pp. 610–618. 11 refs. USAF-Army-Navy supported research.

Circularly-Polarized Biconical Horns. C. Goatley and F. D. Green. *IRE Trans. AP Ser.*, Oct. 1956, pp. 592–596. Method for obtaining circular polarization through the use of a spatial array of thin conducting elements between cone faces.

Applying the Doppler Effect to Radio Direction-Finding. II. Joseph A. Fantoni and Richard C. Benoit, Jr. *Tele-Tech*, Feb., 1957, pp. 66, 67, 124, 128. Description of the bearing indicator, operator-control consoles, bearing storage, performance, and application of the direction-finding system in which fixed antennas, arranged in a circular array to simulate the effect of a moving antenna, are scanned in sequence and transmission direction is determined and plotted by comparing the phase-angle differences between them.

Reflection from and Transmission Through Two Parallel Wire Grids. M. G. Andreasen. *Acta Polytechnica*, No. 2 (192), 1956. 32 pp. 16 refs.

Circuits & Components

Electronic Circuitry. Charles F. Kezer and Milton H. Aronson. *Instruments & Automation*, Jan., 1957, pp. 78, 79. Description of four basic circuits: common-cathode video, common-plate video mixer, transistor preamplifier, and common-collector amplifier.

Analysis of Electric Circuits Containing Nonlinear Resistance. Louis A. Pipes. *J. Franklin Inst.*, Jan., 1957, pp. 47–55. 13 refs. Methods for transient and steady-state analysis and a procedure for determining the steady-stage response of electric circuits having nonlinear resistance.

VHF Pulse Techniques and Logical Circuitry. D. E. Rosenheim and A. G. Anderson. *Proc. IRE*, Feb., 1957, pp. 212–219. 16 refs. Investigation of techniques and components for use in systems handling pulses of 10-millimicrosec. width. The components are used in the design of an arithmetic unit which performs binary addition, multiplication, and dynamic storage at a pulse repetition rate of 50 mc. per sec.

Communications

Instantaneous Speech Compressor. Charles R. Rutherford. *Electronics*, Feb. 1, 1957, pp. 168, 169. Description of a speech compressor combining the advantages of clipper and automatic-gain control types to extend the range of air-to-ground communications systems.

Construction Techniques

A Reliability Approach to Thermal Design and Evaluation. T. C. Reeves. *Elec. Mfg.*, Feb., 1957, pp. 83–89, 330, 332 ff. Methods for arriving at cooling

(Continued on page 136)

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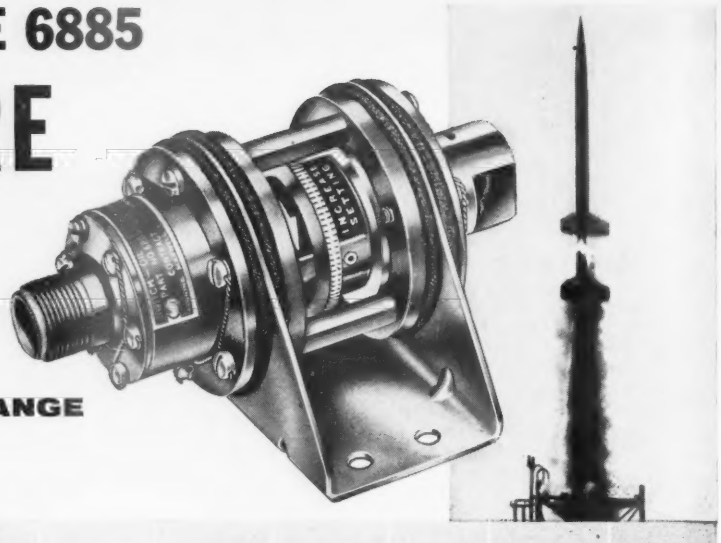

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INTERNATIONAL AERONAUTICAL ABSTRACTS

A Review of Worldwide Scientific and Technical Literature

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AERODYNAMICS

Aerothermodynamics

ON A BOUNDARY CONDITION FOR THE CALCULATION OF THE INTERNAL TEMPERATURE RISE DUE TO AERODYNAMIC HEATING. E. E. Covert. MIT NSL TR 202, Feb., 1957. 19 pp. 11 refs. Detailed analysis of the boundary conditions at the interface between the air and the material in order to estimate the error incurred by the application of the various approximations in general use. The calculations, which are shown for a two-dimensional flat plate and assume quasi-steady boundary-layer heat transfer, proceed from the formulation of the transformed equation governing the wall temperature as an integral equation whose kernel is a product of Green's function for the body and a heat-transfer coefficient. It is shown that the results can easily be extended to three dimensions (either a hemisphere cylinder or a thin plate of known width).

DYNAMICS OF A DISSOCIATING GAS. I - EQUILIBRIUM FLOW. M. J. Lighthill. J. Fluid Mech., Jan., 1957, pp. 1-32. 16 refs. Analysis of the equilibrium statistical thermodynamics of a pure dissociating gas. An approximation is found which greatly simplifies the analysis and yet introduces only small errors for particular gases. The properties of an ideal dissociating gas are given completely once the characteristic temperature, density, and specific energy of dissociation are known. Different pure dissociating gases differ in the values assigned to their constants, but otherwise all have the same thermodynamics; therefore, a single theory will do for all gases. The present method is used to consider the theory of flow in which equilibrium is maintained everywhere and it is shown to give a good approximation to flow outside the boundary layer if the time scale for flow past the body is large compared with the time scale for dissociation or recombination.

AN AERO-THERMODYNAMIC PROPULSION METHOD. S. Lal and I. Michelson. Odin Assoc. Rep. 100-1 (AFOSR TN 56-523) [AD 110341], Sept., 1956. 81 pp. 10 refs. Investigation of the basic aerodynamic and propulsion properties for a propulsive system in which friction heating of the boundary layer is utilized for the vaporization and superheating of an internally circulant coolant fuel. The aerodynamic investigation consists of an examination of heat-transfer properties of boundary layers on three-dimensional configurations at moderate and high Mach Numbers, in relation to the skin friction of the same layers. Computations are carried out for the specific impulse of sample coolant fuels.

INVESTIGATION OF LOCAL LAMINAR HEAT TRANSFER ON A HEMISPHERE FOR SUPERSONIC MACH NUMBERS AT LOW RATES OF HEAT FLUX. I. Korobkin and K. H. Gruenewald. J. Aero. Sci., Mar., 1957, pp. 188-194. 22 refs. Theoretical and experimental investigation on a 2-in.-diam. hemisphere at Mach Numbers up to 4.87. Heat-transfer measurements are made with isothermal temperature distribution over the hemisphere and indicate that the local heat-transfer coefficients are independent of surface temperature. However, the heat-transfer coefficients must be defined in terms of "effective" temperatures rather than adiabatic wall temperatures. From local velocities outside the boundary layer, as determined from static pressure measurements, it is found that the velocity can be made nondimensional, so that a single curve represents the velocity distribution along the hemisphere for the entire Mach Number range.

THE NORMAL SHOCK WAVE AT HYPERSONIC SPEEDS. Z. O. Bleviss and G. R. Inger. Douglas Rep. SM-22624, Nov., 1956. 21 pp. Explanation of the basic physics underlying the exact calculations, available in the literature, of the equilibrium states of air behind a normal shock. Basic normal shock equations and their solutions, strong shock approximations, heat sinks, heat-sink ef-

fects behind normal shocks, relaxation effects, and entropy are discussed.

Boundary Layer

A BOUNDARY LAYER THEOREM, WITH APPLICATIONS TO ROTATING CYLINDERS. M. B. Glauert. J. Fluid Mech., Jan., 1957, pp. 89-99. Study of a theorem evolved by Prandtl which states that if, in a given solution of the boundary-layer equations, the position of the wall is varied, then additional solutions of the boundary layer equations are possible. The theorem is proved for the general case of time-dependent three-dimensional compressible flow. Application is made to a rotating circular cylinder, and explicit formulas are developed for the skin friction, valid for sufficiently low rotational speeds. Discussion also includes slip flow, flow over a body covered in whole or part by a liquid film, and flow over a body of liquid.

THE DIRECTION OF FLOW IN THE LAMINAR BOUNDARY LAYER ON AN INFINITE YAWED CYLINDER. K. D. P. Sinha. Gt. Brit., ARC CP 295, 1956. 57 pp. 17 refs. BIS, New York, $0.99. Analysis to determine the velocity vector, and thus the curvature of the streamlines and the secondary flow, for a class of solutions with a chordwise velocity distribution of $U = U_o x^m$. It is found that the primary flow profiles always lie between the chordwise and spanwise boundary-layer profiles and that the secondary profiles always have a point of inflection. Secondary flows are opposite in direction for positive and negative pressure gradients and are a maximum when the edge streamline makes 45^o with the chordwise direction. An adverse pressure gradient produced a more powerful secondary flow than a favorable gradient of the same strength. Secondary flow instability has been considered in terms of the Reynolds Number of the secondary flow, and curves of the ratio of secondary flow Reynolds Number to the primary flow Reynolds Number are presented for various inclinations of the edge.

BOUNDARY LAYERS WHOSE STREAMLINES ARE CLOSED. W. W. Wood. J. Fluid Mech., Jan., 1957, pp. 77-87. Analysis of boundary layers with closed streamlines for two different cases. For the first case the speed at the solid boundary is assumed to be uniform, the boundary outline to be stationary, and the speed in the boundary layer to differ only slightly from that of the boundary. A formal solution is then obtained for the motion in the boundary layer. This solution confirms that a closed boundary layer may exist and yields a condition needed to determine the inviscid motion. The condition is extracted in a simplified but approximate form and two examples are given. For the second case of uniform pressure, the condition needed to determine the inviscid motion may be derived in a form both simple and exact.

BOUNDARY LAYER GROWTH ON A FLAT PLATE WITH SUCTION OR INJECTION. Hidenori Hasimoto. J. Phys. Soc. Japan, Jan., 1957, pp. 68-72. Solutions of the Navier-Stokes equations for the boundary layer growth on an infinite flat plate started at time t=0. The first solution is for the case of constant suction or injection, and presents simple relations between suction and injection. The second solution considers suction or injection varying as $t^{-1/2}$ and the velocity of the plate proportional to t^{α}. This case presents similar velocity profiles.

BOUNDARY-LAYER TRANSITION AT MACH 3.12 AS AFFECTED BY COOLING AND NOSE BLUNTING. N. S. Diaconis, J. R. Jack, and R. J. Wisniewski. US, NACA TN 3928, Jan., 1957. 17 pp. Experimental investigation of both sharp and blunted cone-cylinder and parabolic-nosed-cylinder bodies at Reynolds Numbers per ft. up to 8×10^6. Results at lower temperature levels indicate that blunting the cone-cylinder model to a nose diameter of 3/16 in. (0.107 of max. body diam.) increases the transition Reynolds Number over that obtained on a sharp model and that delay in transition with surface cooling is greater than that at equilibrium. The latter result is attributed to the increased stability of the boundary layer with cooling. It is further shown that moderate cooling leads to an increase in the transition Reynolds Number on both the cone- and parabolic-cylinder models, but that extreme cooling decreases the transition Reynolds Number. The reversal effect implies that a limiting temperature ratio may exist below which the laminar boundary layer becomes less stable.

EXPERIMENTAL STUDIES ON LAMINAR SUBLAYER IN TURBULENT BOUNDARY LAYER INVOLVING SEPARATION. Yutaka Shigemitsu. J. Phys. Soc. Japan, Feb., 1957, pp. 183-190. Investigation to determine the relation between the mean velocity distribution across the turbulent boundary layer and the effect of pressure gradient of the main stream. Results are shown graphically for the variation of similitude with a pressure gradient and the state of flow near the turbulent separation point.

ON THE HYPERSONIC VISCOUS FLOW PAST A FLAT PLATE WITH SUCTION OR INJECTION. Michiru Yasuhara. J. Phys. Soc. Japan, Feb., 1957, pp. 177-182. Investigation to estimate the effects of suction or injection on the region of strong interaction between the shock-wave and the boundary layer. The Kármán-Pohlhausen method is applied in special cases when suction or injection velocity is proportional to $p_B^{1/2}$ or $x^{-1/4}$, where p_B is the pressure on the plate and x is the distance measured along the plate from its leading edge.

Fluid Mechanics & Aerodynamic Theory

THE USE OF RHEOELECTRICAL ANALOGIES IN AERODYNAMICS. L. C. Malavard. NATO AGARDograph 18 (Paris, NATO AGARD; Washington, NACA), Aug., 1956. 175 pp. 67 refs. Review of the principle of the rheoelectric analogy method; description of the equipment and experimental techniques used in model construction, in the physical realization of the given problem data, in the exploration of the potential fields, and in carrying out the necessary adjustments and measurements; examination of aerodynamic applications including representations of plane flows, studies of airfoil sections and turbine-blade lattices, practical accom-

plishment of conformal mappings, and studies of axially symmetric and three-dimensional flows; and detailed descriptions of the analog methods and setups used for the solution of lifting-line, propeller, lifting-surface, and compressible-flow problems.

TABLES OF CHARACTERISTIC FUNCTIONS FOR SOLVING BOUNDARY-VALUE PROBLEMS OF THE WAVE EQUATION WITH APPLICATION TO SUPERSONIC INTERFERENCE. J. N. Nielsen. US, NACA TN 3873, Feb., 1957. 245 pp. 15 refs. Compilation of tables useful in problems of supersonic flow involving aerodynamic shapes which are wholly or in part quasi-cylinders of nearly circular cross section. A number of uses are described in the aerodynamics of bodies alone, body-body or shock-body interference, wing-body interference, and vortex-panel interference. First, the pressure field due to fuselage indentation is calculated and presented in a form independent of Mach Number. Secondly, the tables are applied to the boundary-layer profiles of a circular cylinder moved impulsively with a constant axial force in a viscous incompressible fluid. In the final example, the wave drag of corrugated circular cylinders is calculated as a function of the number of corrugations and their wave length.

AN AERODYNAMIC MEANS OF STATIC-PRESSURE COMPENSATION FOR TRANSONIC AND SUPERSONIC AIRCRAFT. R. H. Korkegi. Aero. Eng. Rev., Apr., 1957, pp. 64-68. WADC-sponsored description of a method for compensating aerodynamically for the deviation of the measured static pressure at some location on the aircraft from the true free-stream pressure due to the field of flow about the aircraft. The principle of aerodynamic static-pressure compensation is based on the premise that it is possible to produce a desired pressure variation with Mach Number (within certain restrictions as to pressure level and shape of the curve) by proper choice of an aerodynamic body shape and of the location of the pressure source on this body. Treatment includes an example to illustrate the method's application and data from tests in the 2-ft. x 2-ft. transonic wind tunnel of the NACA Ames Laboratory.

ON HYDRODYNAMIC STABILITY IN UNLIMITED FIELDS OF VISCOUS FLOW. N. Curle. Proc. Royal Soc. (London), Ser. A, Jan. 29, 1957, pp. 489-501. 17 refs. Extension of McKoen's method in which the fourth derivative of the velocity function (ϕ'''') is assumed to be significant only near the singular layer, but otherwise the complete fourth-order Orr-Sommerfeld equation is considered. An alternative derivation is given for McKoen's integral form of the boundary condition for an antisymmetrical perturbation. It is shown that the present method will always lead to a neutral stability curve of wave number against Reynolds Number (R), having two branches as $R \rightarrow \infty$, and, hence, a critical R.

QUICK GRAPHICAL METHODS IN COMPRESSIBLE FLOW PROBLEMS. B. Rabineau. Aircraft Eng., Feb., 1957, pp. 39-43. Presentation of a chart for the solution of problems in one-dimensional flow of air or exhaust gas, whether subsonic or supersonic, and for a great number of two- and three-dimensional cases. The method is applicable for normal shock problems involving friction or other losses and, through consideration of normal components, the oblique shocks, as well. The diagram allows instant reading of local values for all the physical and thermodynamic characteristics of the flow at any point, when the initial conditions (either the free-stream, inlet, or stagnation values) and one local characteristic (such as area, pressure, or Mach Number) is known.

ON STOKES' STREAM FUNCTION IN COMPRESSIBLE SMALL-DISTURBANCE THEORY. M. D. Van Dyke. US, NACA TN 3877, Feb., 1957. 15 pp. 10 refs. Analysis of Stokes' stream function for subsonic or supersonic flow past axisymmetric bodies of small slope. Results indicate that the first-order equation is nonlinear and can be linearized only if just the formal order of accuracy of the slender-body approximation is sought. In any case, serious loss of accuracy results from imposing the condition of tangent flow at the body on the mass flux rather than on the velocity. It is further shown that, in a second approximation, neglect of the nonlinearity leads to a false solution even in the slender-body expansion.

PROBLEM OF SLIP FLOW IN AERODYNAMICS. Appendix - THEORY OF TRUESDELL AND IKENBERRY. R. E. Street. US, NACA RM 57A30, Mar. 4, 1957. 29 pp. 38 refs. Survey of the present status of theory in the field of slip-flow aerodynamics, with attention directed to the near-continuous flow domain (modern compressible viscous flow) in which the effects of velocity slip and temperature jump at any boundary of the flow begin to exhibit themselves. Results indicate that the Navier-Stokes equations of motion, together with first-order velocity slip and temperature jump at any boundary, are sufficient insofar as experimental confirmation is available; and that the use of the Burnett terms in the equations of motion, as well as second-order terms in boundary conditions is unjustified - at least for semirarefied gas flows.

INVISCID HYPERSONIC FLOW OVER BLUNT-NOSED SLENDER BODIES. Lester Lees and Toshi Kubota. J. Aero. Sci., Mar., 1957, pp. 195-202. 15 refs. OOR-supported investigation involving energy considerations, a detailed study of the equations of motion, and comparison with experimental data to determine the suitability of similarity theory for predicting shock-wave shape and surface-pressure distribution for various cases. Comparison between theory and results of experiments by Hammitt, Vas, and Bogdonoff on a flat plate with a blunt leading edge at $M_\infty = 13$ in helium indicates that similarity analysis is capable of accurately predicting shock-wave shape but is less satisfactory where surface-pressure distribution is concerned. Data from GALCIT air-tunnel tests on a hemisphere-cylinder at $M_\infty = 7.7$ indicate that both parameters are predicted closely by similarity theory for this body, except near the hemisphere-cylinder junction.

A PRELIMINARY EXPERIMENTAL INVESTIGATION OF THE FLOW OVER SIMPLE BODIES OF REVOLUTION AT M=18.4 IN HELIUM. A. G. Munson. GALCIT Memo. 35, Dec. 15, 1956. 31 pp. 10 refs. Determination of surface pressure distribution and shock wave shapes for a series of "sharp"-nosed and slightly blunted bodies of revolution. The four bodies investigated are as follows: (1) 15° half-angle "sharp" cone, (2) 15° half-angle spherically-blunt cone (bluntness ratio = 0.24), (3) 20° half-angle "sharp" cone, and (4) 2/3-power body. The pressure distributions on the "sharp" cones agree well with the Taylor-Maccoll theory. The pressure near the nose of the blunt cone is much higher than predicted by this theory, but it decreases monotonically to a value lower than the theoretical value on the conical skirt, indicating that the flow has over-expanded. The measured shock wave shape for the 2/3-power body is found to be proportional to $x^{0.69}$ and the shock wave ordinates agree closely with those predicted by Cole and by Kubota and Lees.

AN ELECTRIC-TANK ANALOGY SOLUTION OF A LINEARIZED THEORY FOR THE NORMAL-FORCE ON A SLENDER CLOSED BODY-OF-REVOLUTION. W. B. Brower, Jr. Rensselaer Polytech. Inst. Dept. Aero. Eng. TR AE5701 (AFOSR TN 57-43) [AD 115081]. Feb. 8, 1957. 49 pp. 18 refs. Derivation of a theory which represents the mechanism of normal-force generation by a vortex sheet in the wake, and application of this theory to find the force on a body of revolution slightly inclined to the main stream. The magnitude and distribution of vorticity are determined by imposing a new boundary condition on the body tangential velocity along the zero-meridian line due to the combined effects of the transverse-flow and the vortex sheet. The electric-tank analogy is employed to obtain the solution for a paraboloid of revolution with fineness-ratio 5. Results for the loading coefficient, normal-force distribution, and integrated normal force coefficient are given. Comparisons are made with wind-tunnel results for slender bodies and with an unpublished theory of von Kármán. It is concluded that the slope of the normal-force curve depends mainly on two parameters of the stern geometry - the stern-fineness ratio and the shape of the stern meridian line.

APPLICATION OF THE THIN-WING-EXPANSION METHOD TO THE COMPRESSIBLE FLOW PAST AN ELLIPTIC CYLINDER, WITH SPECIAL REFERENCE TO ITS FOURTH APPROXIMATION. Yaso'o Matunobu. J. Phys. Soc. Japan, Jan., 1957, pp. 72-84. 11 refs. Calculation of the velocity distribution over an elliptic cylinder carried out to the fourth power in thickness t, using both the complete and transonic thin-wing expansion methods. It is found that the fourth order perturbations include not only terms of the order of (t^4), but also those of the order of $(t^4 \log t)$. This latter group becomes negatively predominant over the former in the transonic range. In calculating the fluid velocity near the stagnation point for moderate subsonic flow, the resulting expressions for an elliptic cylinder prove to be transformed into those for a parabolic cylinder.

ON THE STABILITY OF A LAMINAR WAKE. C. H. McKoen. Gt. Brit., ARC CP 303, 1956. 20 pp. 12 refs. BIS, New York, $0.54. Development of a perturbation method for solving the problem of stability in an unlimited flow field. Application is then made to the stability of the laminar wake formed by a flat plate. The necessary and sufficient condition that an integral of the small disturbance equation should satisfy the boundary conditions for the wake is established. This condition leads to a simple determination of the (α, R) curve, which in turn is found for the neutral disturbances. The method fails to predict a minimum critical Reynolds Number because the approximations made in the above conditions are only valid for large Reynolds Numbers.

CONDITIONS NEAR A SONIC LINE IN ROTATIONAL FLOW. M. Holt. Brown U. Div. Eng., WADC TN 56-496 [AD 110579], Dec., 1956. 10 pp. Extention of the method of characteristics for problems of steady supersonic plane flow or flow with axial symmetry, as modified by Holt for the case of isentropic flow, to include hypersonic flow past a blunt body. Results of the analysis which takes vorticity into account show that the flow pattern near the sonic line is not significantly affected by changes in entropy.

A BASIC APPROACH TO SHOCK FRONT ANALYSIS. P. J. Theodorides. U. Md. Inst. Fluid Dynamics & Appl. Math. TN BN-93 (AFOSR TN 57-59) [AD 115099], Jan., 1957. 31 pp. 54 refs. Development of an approach suitable for a nonmonatomic fluid. The initial conditions provide for molecular vibration but assume only negligible disociation, ionization, or radiation of molecules. The basic equations for triaxial flow are set on trimerous viscosity and specialized for steady, uniaxial flow. A new governing equation is derived for the shock front. Though explicitly continuous, the proposed theory harmonizes with the kinetic picture by expressing accordingly the nonlinear viscosity and the specific heats - the latter implying quantum dynamics as to vibratory modes.

THE INTERACTION BETWEEN BOUNDARY LAYER & SHOCK WAVES ASSOCIATED WITH HIGH SPEED AEROFOIL & ON TRANSMISSION OF ENERGY OF SHOCK WAVES. S. K. Banerji. (Aero. Soc. India, 8th Annual Gen. Meeting, Calcutta, Mar. 9, 1956.) J. Aero. Soc. India, Nov., 1956, pp. 69-80. 15 refs. Theoretical investigation to derive basic boundary layer equations using energy methods, and to describe techniques for predicting the thickness and wall temperature for both laminar and turbulent boundary layers.

TRANSITION PROCESSES IN SHOCK WAVE INTERACTIONS. R. G. Jahn. J. Fluid Mech., Jan., 1957, pp. 33-48. 19 refs. Discussion of recent experiments in shock-wave refraction which have clarified a special type of shock outflow process appearing to have relevance to other shock interactions, and notably to shock reflection from an oblique wall. For certain incident shock strengths and angles of incidence (α) the air/methane refraction problem simulates closely the situation in the troublesome

range of the reflection problem, in which α lies between the value α_e at which the theoretical solutions terminate and the value α_0 that marks the onset of Mach reflection. These flow deflections cannot be reconciled with theoretically permissible reflected shock strengths. In the analogous refraction cases, the reflected shock is observed to increase in strength along its length to a maximum value at the intersection point, and to be followed by a subsonic rarefaction zone which also increases in severity near the intersection.

AN EXPERIMENTAL INVESTIGATION OF MEKSYN'S TRANSONIC INVISCID FLOW THEORY. Appendix - A RELAXATION TREATMENT OF MEKSYN'S SOLUTION OF THE TRANSONIC FLOW EQUATIONS. C. S. Sinnott. Gt. Brit., ARC CP 302, 1956. 14 pp. BIS, New York, $0.45. Analysis of the flow past a bicusped airfoil at zero lift to determine the acceptability of Meksyn's solution of the two-dimensional transonic flow equations. Comparison with experimental results shows that the method does not give useful results for mixed subsonic/supersonic flows.

EXPANSION PROCEDURES AND SIMILARITY LAWS FOR TRANSONIC FLOW. I - SLENDER BODIES AT ZERO INCIDENCE. J. D. Cole and A. F. Messiter. ZAMP, Jan., 1957, pp. 1-25. Analysis to provide a detailed and comprehensive account of a transonic approximation as applied to flows past wings and bodies by regarding the approximate transonic equations as part of a systematic expansion procedure. The form of the expansion and the reasons for it are explained and the equations of motion, shock relations, and boundary conditions for the flow problem are derived preliminary to systematic application of the method. The system of equations thus obtained for the first, second, and higher approximations leads to results of practical interest which concern similarity laws and the pressure coefficient on the surface of slender bodies. Bodies of noncircular cross section are also treated.

THE THEORY OF DECAY PROCESS OF INCOMPRESSIBLE ISOTROPIC TURBULENCE. I - FUNDAMENTAL EQUATIONS FOR ISOTROPIC TURBULENCE. II - DECAY PROCESS OF ISOTROPIC TURBULENCE. T. Tatsumi. Proc. Royal Soc. (London), Ser. A., Feb. 12, 1957, pp. 16-45. 24 refs. Calculation of the decay of isotropic turbulence in an incompressible fluid using the assumption that the fourth-order velocity correlation is related to the second-order ones in the same manner as a normal joint-probability distribution of the velocity. A pair of simultaneous differential equations for the energy spectrum (which is the Fourier transform of the second-order velocity-correlation function) are derived. The dynamic properties of these equations are discussed, and the theory is applied to a few typical initial types of energy spectrum. The equations are solved explicitly for an initial spectrum of single-line type and the solutions are compared with experimental data.

SPECTRUM MODIFICATION DUE TO THE USE OF FINITE DIFFERENCES. Y. Ogura. J. Meteorology, Feb., 1957, pp. 77-80. USAF-sponsored analysis of the vorticity spectrum for an isolated turbulence field, the results of which permit a rough estimate of the dependence of the magnitude of vorticity on grid spacing.

Internal Flow

ÉTUDE THÉORIQUE ET EXPÉRIMENTALE DE LA STABILITÉ DES CHAMBRES D'ÉQUILIBRE SITUÉES EN AVAL D'UNE GALERIE EN CHARGE ALIMENTÉE PAR UN CANAL À ÉCOULEMENT LIBRE. Sébastien Gerber. France, Min. de l'Air PST 320, 1956. 119 pp. 41 refs. SDIT, 2, Av. Porte-d'Issy, Paris 15, Frs. 1,400. In French. Theoretical and experimental investigation of the stability of equilibrium chambers located downstream of a gallery fed by a free-flow channel. The case of an infinitely long channel with and without pressure losses is considered, and a simple condition giving the limiting section of the equilibrium chamber over which the damping occurs is established. The cases of a finite channel and of equilibrium shaft are also studied, and the experimental installation is described. Agreement with theoretical results is found.

THE SECONDARY FLOW IN COMPRESSOR BLADES AT HIGH NEGATIVE INCIDENCES. W. D. Armstrong. Gt. Brit., ARC CP 297, 1956. 8 pp. BIS, New York, $0.27. Test results which show that when the blades operate at high negative incidences in nonuniform streams, a variation of outlet angle is obtained which may be qualitatively explained by considering the detailed curvature of the streamlines. This outlet-angle variation is considerably different from that anticipated when the conventional theory is used.

SYSTEMATIC TWO-DIMENSIONAL CASCADE TESTS OF NACA 65-SERIES COMPRESSOR BLADES AT LOW SPEEDS. Appendix - CALCULATION OF BLADE FORCE COEFFICIENTS. L. Joseph Herrig, James C. Emery, and John R. Erwin. US, NACA TN 3916, Feb., 1957. 223 pp. Experimental data indicate a continuous variation of blade-section performance as the major cascade parameters - blade camber, inlet angle, and solidity - are varied over the test range. Summary curves of the data are given to enable compressor designers to select the proper blade camber and angle-of-attack when the compressor velocity and desired solidity are known. An upper limit to satisfactory camber performance is found at a few test conditions. Results provide information as to the maximum value of the loading parameter (expressed as the product of solidity and section-lift coefficient based on the vector mean velocity) that can be used effectively in compressor design.

A THEORETICAL INVESTIGATION OF THE FACTORS AFFECTING STALLING FLUTTER OF COMPRESSOR BLADES. A. D. S. Carter. Gt. Brit., ARC CP 265, 1956. 22 pp. 11 refs. BIS, New York, $0.63. Review of the mechanism for

stalling flutter to establish the major parameters involved. On the basis of the hypothesis advanced, the factors governing the critical flutter velocity are isolated. The variation of this velocity with respect to blade thickness is deduced and compared with test results. Agreement is good, but further work is necessary before the hypothesis can be accepted. Mechanical damping appears to be a major parameter and may severely limit the practical application of the theoretical solution.

TURBULENT DIFFUSER FLOW. Appendix I - A TENTATIVE ESTIMATE OF THE EFFECT OF LINEARISATION ON THE RESULTS FOR TWO-DIMENSIONAL RADIAL FLOW WITH FREE TURBULENCE. B. S. Stratford. Gt. Brit., ARC CP 307, 1956. 64 pp. 14 refs. BIS, New York, $1.35. Derivation of exact solutions for the equations of motion pertaining to that part of a diffuser in which the velocity profile has attained a constant shape. These solutions are expressed in terms of the distribution of the mixing length (effectively, the length of the mean free path of the turbulence) and they yield the value, proportional to the square of the turbulence level, of the critical angle of the diffuser for just avoiding flow separation. If the critical angle is known, use of the solutions in reverse permits an accurate estimate of the turbulence level. Results indicate that, even in a flow which is diffusing rapidly, a narrow wake becomes attenuated and that a large central wake is attenuated if the flow is of moderate diffusion angle. On the other hand, it is suggested that a central wake, especially if produced by a high-turbulence grid, can be used advantageously for preventing flow separation in large-scale diffusers.

EFFECTS OF INLET BOUNDARY LAYER ON PRESSURE RECOVERY, ENERGY CONVERSION AND LOSSES IN CONICAL DIFFUSERS. F. A. L. Winternitz and W. J. Ramsay. J. RAeS, Feb., 1957, pp. 116-124. 10 refs. Description and application of an experimental method in which the conditions of entry are varied by using different approach lengths of diffuser inlet diameter and by means of projecting annular screens of woven wire cloth. Results indicate that the annular-screen method is suitable for diffuser investigations and that energy and pressure coefficients, as well as diffuser energy efficiency and the conversion efficiency, depend on (a) the diffuser angle and (b) the momentum thickness ratio at inlet θ/D_o. It is further shown that, for moderately thick boundary layers, (a) can be eliminated as a parameter by plotting the pressure coefficient against $\theta/D_o \times \rho$.

SOME EXPERIMENTS WITH TWO-DIMENSIONAL CAVITATING VENTURIS. Kurt Berman and T. C. Carnavos. (ARS Fall Meeting, Buffalo, Sept. 24--26, 1956.) Jet Propulsion, Feb., 1957, pp. 148-150. Tests to obtain data on pressure distribution along a venturi as a function of geometry on the cavitating profile by means of high-speed photography, and on flow control by fluid injection. Among the results it is shown that a small flow injected into a venturi will modulate a large flow, and two methods are used to accomplish this modulation.

BOUNDARY-LAYER MEASUREMENTS AT SUPERSONIC NOZZLE THROATS. Merwin Sibulkin. J. Aero. Sci., Apr., 1957, pp. 249-252, 264. USAF-Army-sponsored presentation of wall-static-pressure measurements and boundary-layer pitot-pressure surveys made near the throat of a flexible-wall supersonic nozzle. It is found that the longitudinal static-pressure gradient at the nozzle throat calculated from one-dimensional flow theory agrees with the measured wall-static-pressure gradient. The boundary-layer velocity profiles at the nozzle throat are presented and discussed. It is found that the boundary-layer momentum thickness at the nozzle throat calculated using the momentum integral equation and several approximations agree with the values determined from the measured boundary-layer profiles; that, in spite of the different static-pressure gradients, the boundary-layer velocity profiles for the different nozzle settings are similar; and that analysis predicts this similarity.

Stability & Control

AERODYNAMIC TRANSFER FUNCTIONS: AN IMPROVEMENT OF STABILITY DERIVATIVES FOR UNSTEADY FLIGHT. Appendix - ON THE EXPANSION OF THE TRANSFER FUNCTION AS A POWER SERIES. B. Etkin. UTIA Rep. 42, Oct., 1956. 14 pp. 10 refs. Analysis of aerodynamic forces in unsteady flight using the Laplace transform and the concept of transfer functions. The classical representation of Bryan is replaced by suitable aerodynamic transfer functions, and their relationship to conventional stability derivations is discussed. It is found that the derivatives provide an approximation to the transfer functions which are, in consequence, regarded as generalizations of the derivatives.

AIRPLANE DESIGN IMPLICATIONS OF THE INERTIA COUPLING PROBLEM. R. R. Heppe. IAS 25th Annual Meeting, New York, Jan. 28-31, 1957, Preprint 723. 19 pp. Members, $0.50; nonmembers, $0.85. Review of the inertia coupling problem utilizing the Phillips' simplified criteria to demonstrate the significant airplane natural frequency relationships. It is shown that the practical aircraft configurations do not meet the criteria for satisfactory stability of equal natural frequency values in pitch and yaw throughout their complete speed and altitude spectrum. The critical relationship of natural yaw frequency to satisfactory characteristics for high speed flight is demonstrated, and this relationship shows the prime concern with inertia coupled characteristics to be the high speed and altitude area of flight. The significance of inertia coupling effects in determining the proper design levels of static stability, the selection of controls, the basic structural design loadings to be encountered, and the place of automatic control are discussed.

RECHERCHE DE DÉFINITIONS & DE CRITÈRES DE DIVERGENCE NON OSCILLATOIRE AU VOISINAGE D'UN RÉGIME PERMANENT DE VOL. E. Billion. France, ONERA NT 38, 1956. 57 pp. In French. Evaluation of the expression "static sta-

bility" and study of the phenomena following a perturbation, presenting nonoscillatory character. Only real roots of the characteristic equation governing the system are used. The method is used for several basic regimes including: rectilear regime inside the Earth's gravity field; curvilinear regime outside the Earth's gravity field; and the very general permanent flight regime inside the Earth's gravity field.

THE MEASUREMENT OF NON-LINEAR FORCES AND MOMENTS BY MEANS OF FREE FLIGHT TESTS. C. H. Murphy. U.S. Army Bal. Res. Lab., Aberdeen, Rep., 974, Feb., 1956. 95 pp. 12 refs. Analysis of observations resulting from firing experiments at the Ballistic Research Laboratorys' Spark Ranges to develop a theoretical "equivalent" linear solution method for treating the motion of fired models which either posess known nonlinearities in their force systems or fly at large angles of yaw. The technique is applied to a number of programs fired at BRL in order to demonstrate its value, and extended to predict yawing motion. It is shown that this method more than doubles the value of free-flight ranges for ballisticians and aerodynamicists.

Wings & Airfoils

MESSUNGEN ÜBER DAS ABREISSVERHALTEN VON DELTAFLUGELN. E. G. Feindt. Braunschweig Tech. Hochschule Inst. Strömungsmech., Rep. 56-36, Jan. 17, 1957. 43 pp. In German. Investigation on five delta wings in incompressible flow at Reynolds Numbers up to Re = 1,7 x 10^6. Measurements are obtained on: four delta wings of aspect ratio Λ = 1, 3, 4, and 5 with NACA 0012 symmetrical profile; and one delta wing of aspect ratio Λ = 3 with NACA 0005 symmetrical profile. The critical angle of attack at which the flow separates is determined from wake measurements, using the Hafer method. Results indicate that the smaller the aspect ratio the larger the angle of attack for the delta wing without the occurrence of flow separation. Results further indicate that the flow separation starts at the wing tips and, with rising angle of attack, moves toward the center of the wing.

APPLICATION OF THE M^2-EXPANSION METHOD TO COMPRESSIBLE FLOW PAST ISOLATED AND LATTICE AEROFOILS. Isao Imai. J. Phys. Soc. Japan, Jan., 1957, pp. 58-67. 22 refs. Derivation of general expressions for the velocity components at any point in the flow field, correct to M^4 for an isolated airfoil and to M^2 for a wing lattice. The formula for the velocity distribution on the surface of the airfoil is simplified to reduce the work involved in numerical calculations. The flow past a symmetrical airfoil placed symmetrically in a channel is considered. This problem was dealt with previously by Goldstein and Lighthill by using a different method.

DIE WIRKSAMKEIT VON WÖLBUNGSKLAPPEN IM ÜBERSCHALLBEREICH. Gerhard Schulz. ZFW, Jan., 1957, pp. 15-22. In German. Calculations using linearized supersonic theory for the additional forces and moments on a wing caused by a flap deflection. The analysis considers the lift and flap load, the pitching and the hinge moment, the rolling moment, the induced drag, and the induced yawing moment. The results are applied to a delta wing with flaps.

WIND TUNNEL TESTS ON A 6% TWO-DIMENSIONAL AEROFOIL IN THE TRANSONIC SPEED RANGE. P. E. Turner. Australia, ARL Rep. A.99, Aug., 1956. 44 pp. Presentation of pressure distributions, schlieren photographs of the flow near the trailing edge, and wake-traverse profiles for a modified NACA 64-106 airfoil at zero incidence in the Mach Number range of 0.5 to 1.04. Data obtained by means of natural transition are compared with those obtained by means of transition artificially fixed by roughness close to the leading edge; the variation of lift with Mach Number is discussed with reference to the shock position, with the aid of the schlieren photographs; and, from the wake-traverse profiles, the characteristic "step" obtained at Mach Numbers above 0.9 is explained in terms of the shock-wave pattern near the trailing edge.

TESTS AT HIGH SUBSONIC SPEEDS ON A 10 PER CENT THICK PRESSURE-PLOTTING AEROFOIL OF RAE 104 SECTION. E. W. E. Rogers, C. J. Berry, and R. F. Cash. Gt. Brit., ARC R&M 2863, 1956. 49 pp. 19 refs. BIS, New York, $2.34. Wind-tunnel investigation to determine the force coefficients, surface pressures, and flow patterns for the airfoil through a range of Mach Number incidences up to 8^o. Includes description of the method used - the Frigilene-hand technique - which is shown to be useful when various transition positions are required or when only a limited amount of work with a fixed transition position is contemplated. Results indicate that large differences in flow of the three parameters investigated can be obtained by fixing boundary-layer transition near the nose on both surfaces.

THE REFLECTION EFFECT OF FENCES AT LOW SPEEDS. J. Weber and J. A. Lawford. Gt. Brit., ARC R&M 2977, 1956. 14 pp. 10 refs. BIS, New York, $0.81. Theoretical investigation and pressure measurements on an untapered 45^o sweptback wing. Results substantiate Küchemann's physical explanation of the flow changes caused by fences, and the proportion of full reflection effect is determined experimentally for various fence shapes. Includes description of methods for calculating the changes in pressure distribution and in chordwise and spanwise loading.

NOTE ON THE EFFECT OF SIZE AND POSITION OF END PLATES ON THE LIFT OF A RECTANGULAR WING IN A WIND TUNNEL. A. S. Halliday and D. K. Cox. Gt. Brit., ARC CP 305, 1956. 16 pp. BIS, New York, $0.45. Experimental investigation to determine the minimum size of an end plate which would be effective in producing approximately two-dimensional flow conditions past an airfoil at low incidence. Includes tests on inboard plates showing that two-dimensional condi-

tions can be obtained only if the plates are placed on both surfaces. End-plate data indicates that the lift distribution at the center section is obtained within 10% when the end plates are at least 4/3 c in chordwise extent and their height is at least 2 c above and below the center line. It is further demonstrated that end plates are ineffective on the pressure surface and may over-correct on the suction surface so as to give lift exceeding the two-dimensional value.

THEORETICAL LOAD DISTRIBUTION ON A WING WITH VERTICAL PLATES. Appendix I - THE LOAD DISTRIBUTION ON WINGS WITH A DISCONTINUITY IN CHORD, SECTIONAL LIFT SLOPE OR GEOMETRIC INCIDENCE. J. Weber. Gt. Brit., ARC R&M 2960, 1956. 43 pp. 12 refs. BIS, New York, $2.07. Calculation of spanwise load distribution for wings with plates normal to the wing and parallel to the main stream, or inclined to it at a small angle. The calculations are made for configurations having minimum induced drag. The results are used to obtain an approximation for wings of any plan form, including wings with sweepback. Side-force distributions on the plates, as well as integrated side forces and the moments of the side-force, are calculated.

PRESSURE MEASUREMENTS AND FLOW INVESTIGATION ON DELTA WINGS AT SUPERSONIC SPEED. G. Drougge and P. O. Larson. Sweden, Flygtekniska Försöksanstalten, FFA Medd. 57, 1956. 32 pp. Investigation on two delta wings of 70° sweep, one with a sharp and the other with a rounded leading edge. The tests are made at Mach Number of approximately 1.5 at different angles of attack. From the measurements, the lift distributions are evaluated and compared with the linearized conical-flow theory. The agreement is satisfactory at small angles of attack, but with increasing lift the influence of leading-edge separation becomes apparent. To explore this phenomenon more closely, a detailed investigation of the flow above the surface and in the boundary layer is performed.

REZISTENŢA DE UNDA A UNEI CLASE DE ARIPI DELTA SUBŢIRI DUBLU-CONICE, CU INCIDENŢA VARIABILĂ, ÎN CURENT SUPERSONIC. E. Carafoli and L. Dumitrescu. Stud. Cerc. Mec. Aplic., July-Sept., 1956, pp. 581-598. In Rumanian. Investigation of drag on thin, doubly conical, delta wings with variable incidence in supersonic flow. Includes calculation of the drag coefficient C_{xA} for the cases of a supersonic and a subsonic leading edge. Results indicate that the incidence near the leading edge has a considerable influence on the aerodynamic characteristics of the wing.

THE FUNDAMENTAL MODES OF VIBRATION OF UNIFORM BEAMS FOR MEDIUM WAVELENGTHS. G. J. Kynch. Brit. J. Appl. Phys., Feb., 1957, pp. 64-73. 18 refs. Analysis using the Rayleigh-Ritz method to determine approximate forms for the dispersion curves of a vibrating infinite beam of arbitrary shape. The method is also used to investigate the relations between different types of vibration. The results of flexural vibrations confirm the Timoshenko equation for most beams and include corrections for thin strips. Dispersion curves are obtained for longitudinal-type vibrations which show the variation with shape and the change in classification of the modes when the symmetry of the cross section is altered. When the wave length is of the order of magnitude of the perimeter, the usual longitudinal mode is replaced as the fundamental mode by a new mode.

AEROELASTICITY

SOME EXPERIMENTAL STUDIES OF PANEL FLUTTER AT MACH NUMBER 1.3. Maurice A. Sylvester and J. E. Baker. US, NACA TN 3914, Feb., 1957. 25 pp. Investigation using thin rectangular metal plates mounted as a section of the tunnel wall to verify the existence of panel flutter and to study the effects of some structural parameters on flutter characteristics. Most of the data from the experimental program which consists of three phases - (a) panels clamped front and rear with tension, (b) initially buckled panels clamped front and rear, and (c) buckled panels clamped on all four edges - are obtained from tests on aluminum-alloy panels, although a few steel, magnesium, and brass panels are also used. The effects of various thicknesses and lengths of different materials on panel flutter are also investigated.

THE VORTICAL TRAIL OF A THICK WING OF FINITE ASPECT RATIO OSCILLATING HARMONICALLY WITH A LARGE AMPLITUDE. K. K. Fediaevskii and L. Kh. Bliumina. Soviet Physics - Tech. Physics, Feb., 1957, pp. 594-597. Translation. Analysis of experiments carried out by Iakovenko to determine the dependence of coefficients of translational and rotational derivatives on the relative frequencies of an oscillating wing. The results suggest the existence at large amplitude of a more complicated vortical scheme consisting of both the flat vortical track from the trailing wing edge and of a street of discrete vortices leaving the wing tip near the extreme positions. With the gradual removal of the discrete vortices which leave the wing at extreme positions, the fulfillment of the Chaplygin-Joukowsky postulate can be brought about by the controlling effect of the boundary layer. Since, however, the flat vortical trail is unstable and can be transformed into discrete vortices at some distance from the wing, it is possible to observe only a street of vortices with a counter-Kármán direction of rotation.

THE VARIATION OF GUST FREQUENCY WITH GUST VELOCITY AND ALTITUDE. N. L. Bullen. Gt. Brit., RAE Rep. Struc. 216, Oct., 1956. 12 pp. 11 refs. Analysis of atmospheric turbulence using accelerometer records taken from Hermes aircraft flying over BOAC routes. The effect of flexibility on the aircraft is ignored and the recorded acceleration is assumed to be at the center of gravity of the aircraft. The Zbrozek method is used for the analysis. The gust velocity is assumed to increase linearly to its maximum value. After the conversion of the recorded accelerations,

the number of gusts exceeding each magnitude in the required series is calculated. Relations are given for the variation in gust frequency with gust velocity and altitude, and the results are summarized in a form convenient for estimating fatigue lift.

VIBRATION AND FLUTTER FLIGHT TESTING M. O. W. Wolfe. Gt. Brit., ARC CP 310, 1956, 19 pp. BIS, New York, $0.54. Review of the appropriate techniques that have been or are being developed in the United Kingdom. Includes description of the instrumentation used for recording the vibrational response and a comparative assessment of the various methods used for exciting the aircraft in flutter flight tests.

ÉTUDES ET ESSAIS D'UN AVION ABSORBEUR DE RAFALES. René Hirsch. Docaéro, Jan., 1957, pp. 13-28. 13 refs. In French. Analytical review of gust structure covering longitudinal, transversal, and "angle" gusts. Calculation of the overloading due to gusts, corrections due to aerodynamic effects, and the magnitude of overloading are analyzed. General requirements of a gust absorber, the principle of operation of the device for circulation distribution by automatic-curvature flaps, description of the main system's components, evaluation of the static and dynamic stability, vibration problems, flight and wind-tunnel experiments, and some experimental results are included.

AIRPLANE DESIGN

VIBRATIONS AND DYNAMIC LANDING LOADS OF MAIN LANDING GEAR MOUNTED ON THE WING. E. Mucha. Can. Aero. J., Feb., 1957, pp. 48-55. Derivation of the landing loads for elastic aircraft at the landing-gear axle or bogie pivot in order to obtain proper loads for design and stressing of the undercarriage and fittings on the wing. For the analysis, the aircraft is replaced by an equivalent vibrating system represented by the wings and the shock struts. For the two-wheel symmetric landing cases, the solution of the problem is divided into three parts: (1) the composition and solution of the frequency equations for equivalent vibrating system of the wing, rib, and strut; (2) the calculation of the generalized forces at the landing-gear axles or bogie pivot; and (3) the calculation of the responses at the landing-gear axles or bogie pivot due to the generalized forces for the natural frequencies of the system.

AVIATION MEDICINE

SENSOMOTOR PERFORMANCE DURING WEIGHTLESSNESS; EYE-HAND COORDINATION. S. J. Gerathewohl, Hubertus Strughold, and H. D. Stallings. J. Av. Med., Feb., 1957, pp. 7-12. Experimental investigation to study systematically the effects of changes of acceleration on eye-hand coordination and to determine how well subjects adjust to the various conditions of gravity after repeated practices of the task. A technique is used which permits comparison among three sets of results obtained during normal, increased, and decreased gravitational forces. Sub- and zero-gravity states are produced by flying dives at high altitudes in a T-33 A-type aircraft.

INSTRUMENTS

Flow Measuring Devices

THEORY OF FREE-MOLECULE, ORIFICE-TYPE, PRESSURE PROBES IN ISENTROPIC AND NONISENTROPIC FLOWS. G. N. Patterson. UTIA Rep. 41, Nov., 1956. 15 pp. OSR-supported presentation of a theory for a pressure probe in the form of an orifice in the side of a tube which may be oriented in any direction relevant to that of the mass motion and which is so small compared with the local mean-free path that free-molecule flow occurs. It is shown that such a tube will measure the local speed ratio in isentropic and nonisentropic flows. It is further suggested that it may be possible to determine the viscosity and heat conduction - i.e., the deviation from Maxwellian molecular motion - in strong shock waves.

EFFECTS OF PROBE SIZE ON MEASUREMENTS IN A LAMINAR BOUNDARY LAYER IN SUPERSONIC FLOW. G. R. Ludwig. UTIA TN 9, Nov., 1956. 22 pp. 11 refs. Investigation using total-pressure surveys to determine the effects on the boundary layer of six probes with rectangular tips of various heights and one circular probe. It is found that for a ratio of probe height to apparent boundary layer thickness ≤ 0.26, all rectangular probes show approximately the same pressure profile. At the outer edge, overshoot of the pressure profile is quite noticeable and increases with probe height. This overshoot is attributed to the interaction of the detached shock wave from the probe with the boundary layer. Confirmation of this is shown by schlieren photographs and static-pressure measurements. The circular probe produces a profile which indicates a thinner boundary layer and has less overshoot than the rectangular probe of the same overall height. A method is presented for collapsing all profiles found with the rectangular probes, to one curve.

MACHINE ELEMENTS

Bearings

STRESS-LIFE RELATION OF THE ROLLING-CONTACT FATIGUE SPIN RIG. Appendix - STRESS CALCULATIONS AND PRESENTATION OF BEARING FATIGUE DATA. R. H. Butler and T. L. Carter. US, NACA TN 3930, Mar., 1957. 23 pp. 12 refs. Experimental investigation using the rolling-contact fatigue spin rig to test balls of bearing steel at stresses higher than those produced in bearings, in order to establish the validity of the test for materials comparison and for basic investigation of the factors involved in rolling-contact fatigue. Groups of 9/16-in. SAE 52100 grade 1 steel balls lubricated with a mineral oil are tested at 600,000-, 675,000-and 750,000-psi maximum Hertz stress, at room temperature and on fixed tracts randomly oriented to the fiber direction of the ball. Plain cylinders of commercial- and vaccuum-melt AISI M-1 and commercial-melt AISI M-50 (MV-1)

with a bore size ranging from 3.250 to 3.550 in. are used as race specimens.

MATERIALS

Metals & Alloys

A STUDY OF THE IMPACT BEHAVIOR OF HIGH-TEMPERATURE MATERIALS. H. B. Probst and H. T. McHenry. U.S., NACA TN 3894, Mar., 1957. 23 pp. 12 refs. Results of tests for the impact properties of titanium carbide base cermets, some high-temperature alloys, and the intermetallic, NiAl, taken at room and elevated temperatures up to 1750°F. The impact energies of cermets are found to increase with increased amounts of metallic binder. The composition of an alloy binder influences the resistance to impact failure. Less angular carbide particles result in an improved impact strength of cermets, which are only slightly affected by test temperature. When cermets and alloys are compared on the basis of impact resistance, most cermets are less resistant to impact failure than brittle alloys.

MATHEMATICS

THE LEAST EIGENVALUE OF HILL'S EQUATION. R. A. Moore. Carnegie Inst. Tech., Dept. Math., TR 12 (AFOSR TN 57-48) [AD 115087], Jan., 1957. 18 pp. Analysis exploiting the close connection between the nonoscillation and periodicity of solutions to Hill's equation. An example is given which shows that a known nonoscillation theorem cannot be improved.

ON THE SOLUTION OF THE CAUCHY PROBLEM FOR PARABOLIC EQUATIONS. Bediz Asral. Istanbul U., Fen Fakült, Mecmuasi, Ser. A., Apr., 1956, pp. 65-83. Method for generalizing the Cauchy heat-equation problem to include more general parabolic equations. A function related to the initial value function by an ordinary linear differential equation is substituted for the initial value function in the classical solution of the heat equation.

NIM-TYPE GAMES. E. W. Adams and D. C. Benson. Carnegie Inst. Tech., Dept. Math., TR 13 (AFOSR TN 57-50) [AD 115089], Dec., 1956. 46 pp. Analysis to give a general axiomatic characterization of a class of games similar to Nim, and to develop general properties of the equivalence classes of positions, which are defined as the possible configuration of piles which may occur in the course of the play.

I - ON A PROBLEM OF HEINZ HOPF. II - A THEOREM CONCERNING THE EXISTENCE OF DEFORMABLE CONFORMAL MAPS. III - ASYMPTOTIC SPOTS OF ENTIRE AND MEROMORPHIC FUNCTIONS. Maurice Heins. Brown U. Rep. (AFOSR TN 56-577) [AD 110399], Feb., 1957. 35 pp. 14 refs. I - Establishment of a theorem concerning parabolic Riemann surfaces which, in the parabolic case and in the case of Riemann surfaces having finite topological characteristics, intrinsically contains a negative answer to the problem of whether a Riemann surface with nonabelian fundamental group possesses a nontrivial smooth unbounded covering surface conformally equivalent to itself. II - Establishment of a theorem stating that a hyperbolic Riemann surface belongs to the class D if, and only if, it admits nonconstant analytic functions. III - Analysis of the concept of an asymptotic spot for the special cases of entire and meromorphic functions, with particular attention given to manifestations of countability not found in the general theory and to the relation between the harmonic structure of the asymptotic spots and the growth of the mapping function.

METEOROLOGY

WAVE SOLUTIONS OF THE VORTICITY EQUATION FOR THE $2\frac{1}{2}$-DIMENSIONAL MODEL. Y. Ogura. J. Meteorology, Feb., 1957, pp. 60-64. 19 refs. USAF-sponsored derivation of wave solutions for the nonlinear quasi-geostrophic equations for the so-called "$2\frac{1}{2}$-dimensional model" without friction. The solutions describe wave motions which propagate at different speeds in each layer. The amplitudes of the disturbances are either changing periodically with time (stable waves) or increasing exponentially (unstable waves). The critical value of wave length, at which waves maintain a constant amplitude, is expressed as a function of thermal stability and of vertical wind shear in the basic current. It is also found that, while the inclination of trough lines to the vertical increases monotonically with time in stable waves, it varies very slowly in the unstable waves and tends to approach a certain limiting value.

MILITARY AVIATION & ARMAMENT

A METHOD FOR EXAMINATION OF STORE SEPARATION FROM AIRCRAFT THROUGH DYNAMIC MODEL TESTING AT FULL-SCALE MACH NUMBER. S. J. Deitchman. J. Aero. Sci., Apr., 1957, pp. 275-280. WADC-sponsored development of similarity laws for freely falling bodies and fin- or spin-stabilized powered projectiles near a launching aircraft. Certain simulation errors are examined and evaluated. It is found that testing models of freely falling bodies at full-scale Mach Numbers will probably lead to errors in damping rate and aerodynamic angles of attack and yaw which could be kept under 10% in most test situations. Simulation of motion of powered projectiles without attitude or damping errors is possible if forward acceleration is large with respect to gravity. The motion of spin-stabilized powered projectiles can be simulated only if either Mach Number or Magnus force effects can be neglected. Qualitative examination of the requirements for reproducing, at reduced scale, the motion of a tank with fuel after release indicates that the similarity laws derived for a solid free-fall body will apply.

MISSILES

ON THE MOTION OF A PROJECTILE IN THE ATMOSPHERE. Vi-Cheng Liu. ZAMP, Jan., 1957, pp. 76-81. 11 refs. Derivation of a solution for the equation of rectilinear motion of a projectile which moves in an atmosphere whose

density decreases exponentially with the altitude. It is found that the velocity of the projectile can be expressed explicitly in terms of confluent hypergeometric functions. The theory is applied to treat two specific problems - the flight analysis of a sounding rocket during the free-flight period, and the calculation of ambient temperature from the trajectory of a spherical profile.

PREDICTION OF THE MOTION OF MISSILES ACTED ON BY NON-LINEAR FORCES AND MOMENTS. Charles H. Murphy. U. S. Army Bal. Res. Lab., Aberdeen, Rep. 995, Oct., 1956. 79 pp. 15 refs. Development of a complex-variable technique for a subset of the set of fourth-order systems and application of this technique to the prediction of missile yawing motion. The concept of an amplitude plane is introduced and the analytical results are compared with exact computations. A discussion on the effects of gravity-induced yaw of repose and the influence of small aerodynamic asymmetries on the general nonlinear problem is appended.

PHYSICS

A STUDY OF THE CONDENSATION OF NITROGEN BELOW THE TRIPLE POINT. R. L. Chuan. USCEC Rep. 56-201 (AFOSR TN 57-19) [AD 115052], Feb., 1957. 11 pp. Theoretical investigation of the rate of desposition of solid nitrogen on a cooling surface in order to obtain design criteria for the condensing chamber of the two-phase wind tunnel. Results indicate that it is possible to solve the integral equation characterizing the process through the use of experimental data obtained from a study made at the A. D. Little Laboratory, and that the mass-flow requirements of the tunnel can be met with a condensing surface area of about 60 ft.^{2} for runs lasting up to ten hours.

POWER PLANTS

SU DI UN METODO DI RIDUZIONE DELLE CARATTERISTICHE DI VOLO A TEMPERATURA COSTANTE. Giorgio Aldinio. L'Aerotecnica (Rome), Dec., 1956, pp. 387--394. 10 refs. In Italian. Theoretical investigation of the possibilities, advantages and limitations of a performance reduction method at constant temperature. Correction formulas referring to level speed and rate of climb are developed for supercharged- and reciprocating-engine, turbojet, and turboprop aircraft.

Jet & Turbine

SIMILITUDE CONSIDERATIONS IN TURBOJET ENGINES. S. Way. (ARS Fall Meeting, Buffalo, Sept. 24--26, 1956.) Jet Propulsion, Feb., 1957, pp. 162-168. Theoretical investigation to discuss physical similarity principles in flow and combustion systems, to consider the application of their principles to the separate engine components, and to make observations concerning the engine as a whole. These observations are based on relations derived for the independent and dependent dimensionless parameters for the complete engine.

EXPERIMENTAL COMPARISON OF SPEED - FUEL-FLOW AND SPEED-AREA CONTROLS ON A TURBOJET ENGINE FOR SMALL STEP DISTURBANCES. L. M. Wenzel, C. E. Hart, and R. T. Craig. US, NACA TN 3926, Mar., 1957. 56 pp. Minimization of integral criteria to determine optimum proportional-plus-integral settings for the control of engine rotational speed with fuel flow. Results indicate that optimum speed/fuel-flow control can be satisfactorily predicted by linear theory and that a compromise in optimum speed control is apparently not required for limiting temperature excursions. It is shown that the frequency response of engine speed to exhaust-nozzle area can be represented by a linear lag, specified by the rotor time constant, plus a dead time.

PERFORMANCE STANDARDIZATION FOR A TURBOJET ENGINE EQUIPPED WITH A VARIABLE AREA NOZZLE CONTROLLED BY ENGINE SPEED. R. L. O'Neal. USAF FTC TM 56-7, Mar., 1956. 14 pp. Method of determining performance corrections for an engine equipped with a variable-area jet nozzle and having a single-lever control system. Calculations are presented for the engine in level flight and low-speed cruise, for rate of climb, and for static test conditions.

AN ANALYTICAL METHOD OF EVALUATING THERMAL STRESSES IN GAS-TURBINE BLADES. W. B. Sanders, Jr., and E. A. Trabant. Aero Eng. Rev., Apr., 1957, pp. 52-54. Determination of heat-transfer coefficients, temperature distribution, and stress distribution for three different blade shapes: a flat-plate, tapered section and a varying cross section normal to the chord. The results indicate that tapering the longitudinal cross section of the blade tends to decrease the thermal stress in the leading edge. Conversely, increasing the thickness of the blade along the chord from the leading edge tends to increase the thermal stress in the leading edge. Hence, tapering the longitudinal cross section of the blade and moving the thick section of the blade away from the leading edge tend to decrease the thermal stresses in the leading edge.

EFFECT OF CHORD SIZE ON WEIGHT AND COOLING CHARACTERISTICS OF AIR-COOLED TURBINE BLADES. J. B. Esgar, E. F. Schum, and A. N. Curren. US, NACA TN 3923, Jan., 1957. 37 pp. 11 refs. Theoretical investigation of corrugated-insert blades varying from 1/2 to 3 1/2 in. A two-stage turbine is considered with the blade aspect ratios varying from 1 to 4. Required coolant flow and pressure losses are calculated for an engine with a sea-level pressure ratio of 10, flying at Mach 2.0, at 50,000 ft. The results show that considerable savings in coolant flow are possible by utilizing a smaller number of large-chord blades rather than a larger number of small-chord blades with constant blade solidity. In general, efforts should be made to use blades with as large a chord as appears feasible with regard to disc stress and aerodynamics.

Rocket

PROPULSEURS-FUSEES. M. F. Florio. Tech. et Sci. Aéronautiques, No. 6, 1956, pp. 275-279. In French. Evaluation of the principle of rocket operation and of thermodynamic problems involved. This covers temperatures beyond 3.000° K.; important dissociation of combustion gases; high kinetic energy per volume unit of the combustion chamber and large heat flux through the walls; starting phase reduced to a minimum time; and rapid variation of heat exchangers. The use of new propellants and their handling difficulties are also discussed.

A GENERALIZED CLOSED FORM FOR BURNT VELOCITY. Raimond A. Struble and Harold D. Black. Jet Propulsion, Feb., 1957, pp. 150--155, 168. Closed-form integration of the equation of motion of a rocket, neglecting gravitional-field forces, to yield a useful, easily applied design equation. The method, which makes no assumptions concerning the dependence of the drag and thrust terms, permits facile calculation of the burnt velocity for any variation of the drag coefficient with Mach Number. Calculations and design graphs are given for those drag functions of most practical interest. Analysis includes the case in which the drag coefficient is constant at subsonic velocities, has a finite jump at Mach 1, and decays with increasing Mach Number. Results indicate that, for a specified maximum thrust, definite limits exist on the attainable velocity - this limiting velocity being independent of the propellant-mass/inert-mass ratio.

PRODUCTION

Metalworking

BOUNDS FOR THE COLLAPSE LOAD OF A BEAM COMPRESSED BY THREE DIES. W. Freiberger. Australian J. Phys., Dec., 1956, pp. 419-424. Theoretical investigation of the plastic deformation of a beam under the action of three perfectly rough, rigid dies, two of which are applied to one side of the beam while the third, situated between these two, is applied to the other side. The problem is treated as one of plane plastic flow. Discontinuous stress and velocity fields are assumed and limit analysis is used to obtain an approximate prediction of upper and lower bounds for the pressure sufficient to cause pronounced plastic yielding.

ROTATING WING AIRCRAFT

APPLICATION OF PROBABILITY CONCEPTS TO TRANSMISSION LIFE DETERMINATION. E. K. Liberatore. AHS J., Jan., 1957, pp. 30-38. Study to show the relationship between helicopter transmissions and the laws of probability with regard to maintenance, bench testing, and theoretical analysis. Available maintenance data is summarized and an approach to bench testing, applicable to a simulated-load bench test in a programed system, is presented. Analysis results in the derivation of a method for predicting the normal distribution of a transmission by a study of the individual lives of its bearings.

A COMPARISON OF THE CALCULATED AND OBSERVED FLUTTER CHARACTERISTICS OF A HELICOPTER ROTOR BLADE. Leonard Goland and A. A. Perlmutter. J. Aero. Sci., Apr., 1957, pp. 281-290, 320. Army-Navy-sponsored derivation of a method for predicting rotor-blade flutter, including effects due to the rotation of the blades. The method is based on a Rayleigh-type analysis similar to that developed for fixed-wing flutter predictions. Considering the nature of the phenomenon and the simplifying assumptions made, the results show that the calculated values compare favorably with the test data. For the rotor tesed, the effects of unsteady aerodynamics are found to have a major influence on the flutter speed and frequency.

APPROXIMATE SOLUTION FOR STREAMLINES ABOUT A LIFTING ROTOR HAVING UNIFORM LOADING AND OPERATING IN HOVERING OR LOW-SPEED VERTICAL-ASCENT FLIGHT CONDITIONS. Appendix A - SOLUTION FOR INITIAL WAKE RADIUS r_0 FOR HOVERING AND VERY LOW RATES OF VERTICAL ASCENT. Walter Castles, Jr. US, NACA TN 3921, Feb., 1957. 41 pp. Analysis which shows that the usual assumption of a uniform vortex cylinder for the wake vortex structure of a uniformly loaded lifting rotor operating in the hovering or low-speed vertical-ascent flight conditions does not yield useful results for the induced velocities in the region about the periphery of the rotor. A more realistic approximation for the low-speed flow patterns can be obtained by adding the stream function for the displacement velocity of a disc and the stream function for a ring source coincident with the rim of the rotor to the stream functions for the uniform vortex cylinder and a free-stream velocity. Equations are derived for the relative strengths of the stream functions that are necessary to satisfy certain selected physical conditions.

HELICOPTER LONGITUDINAL STABILITY IN FORWARD FLIGHT WITH CONTROL FEEDBACK AND FUSELAGE AERODYNAMICS. K. G. Wernicke. (AHS 3rd Annual Western Forum, Dallas, Oct. 7-9, 1956.) AHS J., Jan., 1957, pp. 11-24. 12 refs. Evaluation of longitudinal stability and the effects of fuselage pitching-moment characteristics for a small single-rotor helicopter with various types of feedback. Analysis is based on solutions from an analog computer and it is found that the control displacement due to feedback is proportional to changes in each of the following variables (with zero time lag), considered separately: pitch attitude, pitching velocity, normal acceleration, and angle of attack.

AN ACCOUNT OF SOME LONGITUDINAL STABILITY TESTS ON A DRAGONFLY HELICOPTER. Appendix A - SIMPLIFIED ANALYSIS OF THE IDEALIZED PULL-OUT MANOEUVRE. J. D. L. Gregory, G. F. Langdon, and R. W. Coombes. Gt. Brit., AAEE Rep. Res/293, Jan. 7, 1957.

15 pp. Includes description of techniques for measuring static and maneuver margins. Results of such measurements are presented together with the longitudinal trim curve and the results of pull-up tests. These data demonstrate the near equivalence of the maneuver margin and pull-up tests.

SPACE TRAVEL

A NEW TYPE OF NUCLEAR POWER FOR SPACE FLIGHT. R. L. Carroll. ARS 11th Annual Meeting, New York, Nov. 26--29, 1956, Preprint 375-56. 30 pp. Theoretical investigation to develop a type of nuclear reaction which is the reverse of fusion and which, because it provides mass in motion with high velocities (25,000 mi./sec.), is naturally applicable to the problem of rocket propulsion for space travel. Includes calculations indicating the advantages of such a fuel over the present chemical fuels. It is shown that the reaction can be made self-sustaining as long as reacting material is present and that it can be confined within the walls of a solid material. The rate of reaction can then be controlled by the rate at which fuel is introduced.

THE DESCENT OF AN EARTH-SATELLITE THROUGH THE UPPER ATMOSPHERE. D. G. King-Hele. J. Brit. Interplanetary Soc., Nov.-Dec., 1956, pp. 314-323. Analysis of the flight path of an uncontrolled but aerodynamically stable satellite as it spirals down through the Earth's atmosphere from an initially circular orbit under the action of air drag. The Earth and its atmosphere are taken as spherically symmetrical. For altitudes above 125 nautical miles a simple solution is found. It is shown that the velocity of the satellite is independent of its size, shape, weight, and initial altitude, and equal to the orbital velocity appropriate to its current altitude; its angle of descent, in radius, is twice its drag/weight ratio. Estimates are also presented for the satellite's lifetime.

HEAT TRANSFER TO SATELLITE VEHICLES RE-ENTERING THE ATMOSPHERE. Appendix A - STAGNATION POINT HEAT TRANSFER RATES IN CONTINUUM FLOW. Appendix B - CONSTANT HEAT TRANSFER TRAJECTORIES. N. H. Kemp and F. R. Riddell. (ARS 11th Annual Meeting, New York, Nov. 26--29, 1956.) Jet Propulsion, Feb., 1957, pp. 132--137, 147. Application of the Fay-Riddell theory of heat transfer at high velocities and high altitudes to the problem of a satellite vehicle entering the atmosphere. Circular reentry orbits are considered for bodies under the influence of gravity and drag forces. Numerical results are presented which can be used to determine the conditions under which the survival of such a satellite may be expected. Includes analysis of the value of exerting a lift force on the reentering vehicle as a means of preventing its destruction.

SKIN TEMPERATURES OF A SATELITE. C. M. Schmidt. ARS 11th Annual Meeting, New York, Nov. 26--29, 1956, Preprint 383-56. 23 pp. Numerical computations to develop a feasible satellite configuration by considering a nonrotating (about its own axis) cylindrical shell with one end pointing earthward at all times. The analysis is largely geometric, involving spacewise as well as timewise variations in skin temperature. Results indicate that the skin temperatures that would exist are dependent on the density, specific-heat, emissivity, and absorptivity properties of the surfaces and that large values of the two latter properties produce the widest range in surface temperatures; by proper choice of these parameters, this range can be controlled.

STRUCTURES

FATIGUE DES STRUCTURES D'AVIONS. W. Barrois. Docaéro, Jan., 1957, pp. 29-50. 34 refs. In French. Investigation of structural fatigue in aircraft. Study includes: gust loads; force spectra; gust velocities; the distance to be covered in order to encounter specific-velocity gusts; method for calculating repeated loads, using the theory of functions of uncertain variables and of harmonic analysis; method for evaluating the fatigue life and survival probability; calculation of damage; and crack and crack-propagation control.

THEORIES OF STRENGTH FOR COMBINED STRESSES AND NONISOTROPIC MATERIALS. Joseph Marin. J. Aero. Sci., Apr., 1957, pp. 265-286, 274. 13 refs. Derivation of theories of failure for defining strength for various states of combined stresses as applied to materials with different strengths in different directions. A theory is also developed for defining strengths under combined strengths in the case of materials with different strengths in tension and compression.

Beams & Columns

STRESS DISTRIBUTION IN THIN-WALLED WIDE-FLANGED BEAMS. S. Krishnan. J. Aero. Soc. India., Nov., 1956, pp. 81-87. Analysis for the stress distribution in a wide-flanged I-Beam by assuming a stress function in the form of a trigonometrical series and using the Raleigh-Ritz method. Three cases of loading on a simply supported beam are considered: (1) uniformly distributed load, (2) uniformly increasing load, and (3) concentrated load at the center. Results show that convergence is quite rapid, particularly for flange widths less than a fourth of the span. Curves showing equivalent widths and ratios of maximum to minimum bending stresses are plotted.

Connections

THE FATIGUE STRENGTH OF RIVETED JOINTS. C. R. Smith. Aircraft Eng., Feb., 1957, pp. 34-38. Results of fatigue tests and strain measurements on riveted joints are presented. It is found that in addition to rivet pattern, thickness of splice plates play an important part. An improvement in fatigue strenght of butt joints is obtained by laminating the splice plate so that the first row of rivets engage only the first of the laminates. The increase in life is attributed to a decrease in bending stress at the first row of rivets and to a more equal load distribution between the first and second rows of rivets. It is

also shown that static overloading prior to fatigue testing is harmful in some cases and beneficial in others.

RESEARCH ON CUMULATIVE DAMAGE IN FATIGUE OF RIVETED ALUMINUM ALLOY JOINTS. J. Schijve and F. A. Jacobs. Netherlands, NLL Rep. M. 1999, Jan., 1956. 53 pp. 27 refs. ARDC-sponsored results of an investigation on 24S-T Alclad riveted lap joints to verify the linear cumulative damage rule. Available data on light-alloy specimens are reviewed and compared with the results of the present investigation. An attempt is made to establish some general trends for the cumulative damage phenomenon. Proposed cumulative damage rules are discussed with respect to the experimental results and accepted general features of the fatigue phenomenon, and remarks are made on the life estimation of structures under service loading.

Cylinders & Shells

LOWER BUCKLING STRESS OF CIRCULAR CYLINDRICAL SHELLS SUBJECTED TO TORSION. Yoshimaru Yoshimura and Jun'etsu Niisawa. J. Aero. Sci., Mar., 1957, pp. 211-216. Analysis to explain the discrepancy between the small deformation theory and experimental results for the critical stress in torsional buckling of a cylinder. The clarification is based on the assumption that torsional buckling as well as compressive buckling is a Durchschlag phenomenon. This phenomenon is due to the fact that the buckled surface is approximately developable. Therefore, the equilibrium state after buckling, which has as low a potential energy as that just after buckling, does exist. The equilibrium state after buckling is determined by minimizing the potential energy, based on the finite deformation theory, with respect to all the parameters which characterize the wave pattern of buckling. The results of the calculations show that the lower buckling load exists for the case of buckling under dead load, which is smaller than the critical stress by the linear theory, and explains the experimental results approximately.

PLASTIC STABILITY THEORY OF THIN SHELLS. George Gerard. J. Aero. Sci., Apr., 1957, pp. 269-274. Derivation of a set of equilibrium differential equations for the plastic buckling of thin shells of constant unequal radii. This set of three equations applies to flat plates, cylinders, and spheres under any loading system leading to buckling. For particular problems, such as buckling of cylinders under axial compression, torsion, or lateral pressure, and spheres under external pressure, the set of equations can be reduced to a single eighth-order partial differential equation of the Donnell type in terms of radial displacement only. These Donnell-type equations are used to obtain solutions for plastic buckling of spheres under external pressure and for long and moderate-length cylinders under lateral pressure or torsion loads.

KRAFTEINLEITUNG IN VERSTEIFTE KREISZYLINDERSCHALEN. II - DIE SCHALE MIT ENDLICH VIELEN SPANTEN. Walter Schnell. ZFW, Jan., 1957, pp. 1-12. In German. Solutions, in matrix form, of basic equations for the orthotropic cylindrical shell developed previously. Using the "matrices of determinants", a concise solution is also possible for shells of arbitrary shape in an axial direction. Due to an additional simplification of the matrices, the transformation into a difference equation is possible. Limits for the applicability of the simplified assumptions are obtained from a comparison of the results obtained in turn from three methods of solution (orthotropic calculation, difference equation, matrices).

PLASTIC TORSIONAL BUCKLING STRENGTH OF CYLINDERS INCLUDING THE EFFECTS OF IMPERFECTIONS. L. H. N. Lee and C. S. Ades. J. Aero. Sci., Apr., 1957, pp. 241-248, 264. 13 refs. Derivation of both an energy solution and a more exact solution based on a plastic stress-strain relationship given by the simple deformation theory. Close agreement between the two solutions is found. The effects of large deflections and imperfections on buckling strength are analyzed. For two groups of experimental results used for comparison, the effects of geometrical imperfections in the plastic range are negligible.

POSTBUCKLING BEHAVIOR OF CIRCULAR CYLINDRICAL SHELLS UNDER HYDROSTATIC PRESSURE. Joseph Kempner, K. A. V. Pandalai, S. A. Patel, and Jacques Crouzet-Pascal. J. Aero. Sci., Apr., 1957, pp. 253-264. 13 refs. ONR-sponsored investigation of postbuckling behavior using the principle of stationary potential energy together with appropriate approximate deflection functions. Calculations show that postbuckling equilibrium configurations exist for loads greater or less than the critical load calculated from small-deflection theory. Loads less than the critical load are obtained only for a finite range of a parameter indicative of shell geometry. For loads corresponding to radial displacements for the order of the shell thickness, it is found that the number of circumferential waves remains essentially constant with increasing deflection and equal to the number of waves developed at buckling.

NONAXIALLY-SYMMETRIC MOTIONS OF CYLINDRICAL SHELLS. I. Mirsky and G. Herrmann. Columbia U. Inst. Flight Struc. TN 3 (CU-11-56-AF-1247-CE), Dec., 1956. 58 pp. Derivation of a general Timoshenko-type theory of cylindrical shells to include the usual membrane and bending effects in addition to the effects of transverse shear deformation, rotary inertia, and non-axially-symmetric motions. A previous work on axially-symmetric motions alone is included as a special case. The dependence of the displacement on the radial coordinate is specified at the outset, and the stress equations of motion for the shell are derived by a direct application of Hamilton's principle. The stress-displacement relations are established by performing appropriate modifications of Hooke's law for an isotropic three-dimensional solid. As an application, the propagation of free harmonic waves in the axial direction of a shell of infinite extent is studied.

Plates

PLASTIC BUCKLING OF SIMPLY SUPPORTED PLATES SUBJECTED TO COMBINED SHEAR AND BENDING OR ECCENTRIC COMPRESSION IN THEIR PLANE. P. P. Bijlaard. J. Aero. Sci., Apr., 1957, pp. 291-303. 26 refs. OOR-sponsored derivation of formulas for computing the plastic buckling stress using the energy method and oblique coordinates. The integration in the plastic regions is carried out partially by using Simpson's rule. The more general case of combined shear and eccentric compression is also considered. An evaluation is made for these computations in some definite cases. Simple design formulas are presented for computing the plastic reduction factor, with which the elastic buckling stress for the so-called associated elastic case must be multiplied in order to obtain the plastic buckling stress. An approximate formula is presented for calculating the elastic buckling stress for combined shear and eccentric compression.

SOME PROBLEMS OF STRUCTURAL ANALYSIS OF PLATES WITH MIXED BOUNDARY CONDITIONS. W. Nowacki and S. Kaliski. Bul. Acad. Polonaise Sci. (Warsaw), No. 4, 1956, pp. 235-246. Analysis of plates with discontinuous boundary conditions, taking into account the elastic support and the elastic clamping on the edges and inside the plate region. The solution is reduced to a system of Fredholm integral equations of the second kind which in certain particular cases become Fredholm equations of the first kind.

VIBRATION, BUCKLING AND BENDING OF A CIRCULAR PLATE CLAMPED ALONG PART OF ITS PERIPHERY AND SIMPLY SUPPORTED ON THE REMAINING PART. W. Nowacki and Z. Olesiak. Bul. Acad. Polonaise Sci. (Warsaw), No. 4, 1956, pp. 247-258. Analysis of the problem of forward vibration due to a periodic load perpendicular to the plate which is also loaded by a compulsive force acting in the middle of the plate. The solution is obtained by using a Fredholm integral equation of the first kind.

CONTRIBUTION A LA DÉTERMINATION MATHÉMATIQUE APPROCHÉE DES CONTRAINTES DANS LES PLAQUES. Francisque Salles. France, Min. de l'Air PST 321, 1956. 160 pp. SDIT, 2, Av. Porte-d'Issy, Paris 15, Frs. 2,000. In French. Approximate mathematical determination of strains in plates loaded in their plane by substituting a different structure. Includes a study of long plates, followed by a numerical computation. A grid of fictitious columns is used to solve the highly hyperstatic systems, and an attempt is made to orthogonize them. The indicated applications include bending of hollow beams, study of caissons, and means of expressing the displacements as strain functions.

Thermal Stress

CIRCULAR CYLINDER UNDER PERIODIC FLUCTUATIONS OF TEMPERATURE. Václav Vodička. ZAMP, Jan., 1957, pp. 53-64. Detailed calculations leading to general formulas for heat waves in homogeneous isotropic cylindrical bodies in periodic temperature fields. These formulas implicitly include the results available in the literature as special cases.

REGULARITIES IN CREEP AND HOT-FATIGUE DATA. I, II. A. Graham and K. F. A. Walles. Gt. Brit., NGTE Rep. R.189; R.190, Dec., 1956. 25; 143 pp. 26 refs. Analysis of published data on the creep rupture and hot fatigue of engineering materials, carried out by means of a previously given theory of uniaxial deformation which is supported by a correlation of published experimental results. The theory permits data for different times and temperatures to be classed together in order to provide information over a greater range of times than can feasibly be covered by experiments at a single temperature. An underlying numerical pattern common to all the widely different Group VIII materials considered shows through the experimental scatter and, in terms of this pattern, the theory is further compared with 103 sets of published creep-rupture, creep-rate, and hot-fatigue data relating mainly to alloys of the Fe, Ni, Cr, Co system of 44 different compositions. The results of all analyses are given in detail in the figures and tables which provide a convenient source of reference to the mean properties and their probable deviations for many materials. A statistical assessment of the extent of agreement of the theory with the data is given with reference to the number of free constants used.

THERMODYNAMICS

Combustion

A GENERAL SYSTEM FOR CALCULATING BURNING RATES OF PARTICLES AND DROPS AND COMPARISON OF CALCULATED RATES FOR CARBON, BORON, MAGNESIUM, AND ISOOCTANE. Appendix A, B - DETAILS OF BORON TREATMENT. Appendix C - REDUCTION OF GENERAL EQUATIONS TO SIMPLIFIED EQUATIONS. Appendix D - DERIVATION OF APPROXIMATE DIFFUSION EQUATIONS FOR MULTICOMPONENT MIXTURES. Appendix E - ESTIMATION OF δ_i FOR CARBON AND BORON COMBUSTION. K. P. Coffin and R. S. Brokaw. US, NACA TN 3929, Feb., 1957. 56 pp. 12 refs. Calculations carried out by two methods: (1) a numerical integration of considerable complexity, and (2) a somewhat less complicated and less rigorous analytical solution involving stepwise iteration across the temperature profile. The direct results of the calculations are partial pressures as a function of temperature. Simple additional calculations produce the burning rate and the flame structure. For a series of substances covering a wide range of volatility, relative heat-release rates are in the order: hydrocarbon > magnesium > carbon ≅ boron.

DESIGN OF AN APPARATUS FOR THE MEASUREMENT OF THE COMBUSTIBILITY HAZARD OF GASES IN AIRCRAFT AND OTHER APPLICATIONS. E. J. Durbin. Aero. Eng. Rev., Apr., 1957, pp. 58-63. Development of a system by

means of which potentially explosive gases and vapors are continuously sampled and measured for combustibility in order to provide a warning when such combustibility approaches a dangerous condition and to evaluate the effectiveness of ventilating systems or other safety devices intended to reduce this explosive hazard.

EFFECT OF TURBULENCE ON RADIATION INTENSITY FROM PROPANE-AIR FLAMES. Richard R. John and Martin Summerfield. Jet Propulsion, Feb., 1957, pp. 169-175, 178, 179. 26 refs. Measurements to determine the extent of the possible interaction between the mixing process and the chemical reaction. Results of energy tests carried out with a standardized photomultiplier through three interference filters (centered, respectively, at 4,500 Å for CO background radiation, 5,150 Å for C_2, and 4,300 Å for CH) verify the hypothesis that the turbulent flame is a deep zone of chemical reaction rather than merely a distorted laminar flame. This verification is implied by the experimental observations that the turbulent mixing breaks up what would be a continuous laminar flame sheet and that this breakup modifies the chemical reaction and transport processes in the flame zone.

PROPAGAREA ARDERII ÎN CANALE CU SECTIUNE VARIABILĂ. E. Larisch. Stud. Cerc. Mec. Aplic., Oct.-Dec., 1956. pp. 863-873. In Rumanian. Derivation of an integral equation describing the laminar flow propagation in divergent channels. The procedure is the same as that given by Tsien for the channel profiles with parallel walls. By solving this equation, formulas are obtained for the channel profiles in which flame propagation generates a definite flow. A method is then indicated, furnishing the solution of the direct problem for a channel whose walls are polygonal. The present theory can be used for calculating the burned phenomenon in ram-jets.

Heat Transfer

RADIANT-HEAT TRANSFER BETWEEN NON-GRAY PARALLEL PLATES. Stanley Goodman. J. Res., Jan., 1957, pp. 37-40. 10 refs. ONR-sponsored calculation of radiant heat-transfer rates between infinite parallel plates for Inconel and aluminum over a wide range of plate temperatures. Results indicate that assuming the plates to be gray-bodies introduces an error of 2 to 29% in the computed heat-transfer rate. In cross-sectional heat flow between box beams it is found that radiant heat transfer predominates in Inconel beams and is significant in aluminum beams.

VTOL & STOL

WIND-TUNNEL INVESTIGATION OF EFFECT OF PROPELLER SLIPSTREAMS ON AERODYNAMIC CHARACTERISTICS OF A WING EQUIPPED WITH A 50-PERCENT-CHORD SLIDING FLAP AND A 30-PERCENT-CHORD SLOTTED FLAP. R. E. Kuhn and W. C. Hayes, Jr. US, NACA TN 3918, Feb., 1957. 72 pp. Uncorrected results of tests in the Langley 300 m.p.h. 7- by 10-ft. tunnel indicating that stalling occurs in conditions approaching steady level flight at high-power conditions but that a leading-edge slat effectively delays this stall.

WATER-BORNE AIRCRAFT

THE EFFECT OF CHINE FLARE ON THE SPRAY CHARACTERISTICS OF A MODEL OF THE JRF-5. F. W. S. Locke, Jr. US, NavBuAer DR 1842, Nov., 1956. 39 pp. Investigation on a JRF-5 float model which shows that spray tips, as used on the Japanese "Emily" flying boat, reduce the spray height 38% over the bare hull spray. More conventional spray strips located at the chine of the JRF-5 model produce considerably larger reduction in spray height. The maximum reduction is found to be 61%, by means of a vertical spray strip which is 9% of the beam height. It is shown that the results of these tests apply only to smooth water, and that many of the conclusions may reverse in rough or choppy water.

WIND TUNNELS & RESEARCH FACILITIES

DEVELOPMENT OF A TRANSONIC SLOTTED WORKING SECTION IN THE NAE 30-INCH X 16-INCH WIND TUNNEL. J. A. Laurmann and J. Lukasiewicz. Canada, NAE LR 178, Aug., 1956, 52 pp. Experimental investigation of several designs to develop a working section free of solid blockage interference. A final configuration is obtained which gives a maximum variation of flow in Mach Number of $\pm$ 0.01 up to M = 1.08. Transonic operation of the tunnel without choking is shown to be possible with half models of up to 21/2% blockage. Tunnel wall interference is found to be negligible up to sonic velocities with 1% blockage models and up to M = 0.95 with a 2-1/2% blockage model. Interference effects are inconsiderable for all of the models throughout the complete speed range tested.

THE USE OF MULTIPLE DIAPHRAGMS IN SHOCK TUBES. B. D. Henshall. Gt. Brit., ARC CP 291, 1956. 44 pp. BIS, New York, $1.08. Calculations illustrating the advantages of various types of multiple-diaphragm shock tubes over the conventional single-diaphragm shock tube. Includes consideration of shock tubes having a discontinuous change of cross section at a diaphragm station or at any other position along the tube.

SOME NOTES ON THE FLOW DURATIONS OCCURRING IN HYPERSONIC SHOCK TUBES. B. D. Henshall. Gt. Brit., ARC CP 290, 1956. 15 pp. 10 refs. BIS, New York, $0.45. Review of the aerodynamic principles involved in the production of very strong shock waves and high Mach Number flows. The effects are considered for the deviations from the perfect gas theory which occur when strong shock waves are generated. Calculations of the duration of the flow occurring in hypersonic shock tubes are presented in tabular and graphical form. It is found that the influence of the gaseous imperfections is such that the flow durations are reduced - about 50% for strong shocks.

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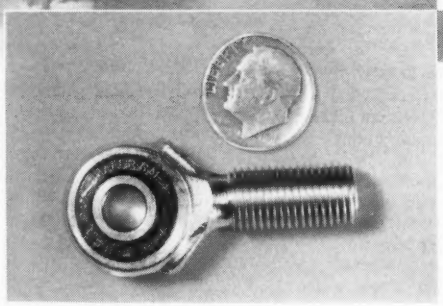

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requirements based on acceptable failure rates as determined by reliability goals and for evaluating developmental or final designs in terms of the effect of the thermal design on reliability. Mean life of electronic components is considered a continuous function of temperature level.

Electronic Subminiaturization Techniques. *Tech. News Bul.*, Jan., 1957, pp. 3–5. Discussion of methods for making commutator-type gain controls, temperature-compensated permeability-tuned inductors, high-temperature Litz wire, and efficient IF transformers.

Vibration Testing for the Neophyte. Robert L. Stallard. *Environmental Quart.*, Fourth Quart, 1956., pp. 4, 5, 7, 16, 17, 19, 21, 25. Discussion of test procedure for vibration-testing electronic equipment to meet military specifications.

Cooling

Heat Control in Electronic Equipment. II. E. N. Shaw. *Electronic Eng.*, Feb., 1957, pp. 65–70.

Kylning av Flygelektronik. Klas Küntzel. *Teknisk Tidskrift*, Jan. 1, 1957, pp. 11–14. Analysis of the problem of cooling air-borne electronic equipment.

Delay Lines

Distributed-Parameter Variable Delay Lines Using Skewed Turns for Delay Equalization. F. D. Lewis and R. M. Frazier. *Proc. IRE*, Feb., 1957, pp. 196–204. 13 refs.

Electronic Tubes

Operation of a Cold Cathode Gas Triode in a High Impedance Self-Biasing Circuit. Marvin Silver. *Proc. IRE*, Feb., 1957, pp. 239–242.

The Life and Reliability of Valves. K. Rodenhuis, H. Santing, and H. J. M. van Tol. *Philips Tech. Rev.*, Dec. 15, 1956, pp. 181–192. 15 refs.

Magnetic Devices

Audio Transformer Design Short Cuts. Robert T. Henszey. *Tele-Tech*, Feb., 1957, pp. 60–62, 130. Description of a step-by-step procedure for completing developmental models in a few hours.

Field Homogeneity and Pole Distribution. J. D. Bjorken and F. Bitter. *Rev. Sci. Instr.*, Dec., 1956, pp. 1,005–1,008. USAF-Army-Navy-supported investigation of a magnet model whose distribution of magnetic poles has two adjustable parameters.

Transducer Characteristics; Measurement of Displacement, Velocity, Acceleration. H. G. M. Spratt. *Elec. & Radio Engr.*, Jan., 1957, pp. 2–8. Discussion of the principles of transducer operation, and description of some representative types.

Measurements & Testing

Measurement of Instantaneous Frequency with a Microwave Interferometer. Herbert P. Raabe. *Proc. IRE*, Jan., 1957, pp. 30–38. Description of a microwave interferometer consisting of a frequency-modulation discriminator, and of an indicator consisting of a microwave detector, video amplifier, and oscilloscope.

The Vernier Time-Measuring Technique. Robert G. Baron. *Proc. IRE*, Jan., 1957, pp. 21–30. Description of a measuring technique which is the electrical analog of the mechanical scale.

Standardized White Noise Tests. J. Robbins. *Tele-Tech*, Feb., 1957, pp. 68, 69, 114–122 ff. Description of the theoretical basis for the wide-frequency, high-*g* tests for missile components which give simple noise readings and are adaptable to large-scale testing. Equipment, attenuation, and the vibration noise output voltage of the tube under test are also described.

Networks

The Characteristics of Parallel-T RC Networks. D. H. Smith. *Electronic Eng.*, Feb., 1957, pp. 71–77. 11 refs. Investigation presenting typical curves of magnitude and phase of the transmission ratio for both balanced and unbalanced networks. It is shown that a a single-stage amplifier with a balanced network in the feedback path will not in general tune to the null-point frequency.

Noise & Interference

Measured Statistical Characteristics of VLF Atmospheric Radio Noise. A. D. Watt and E. L. Maxwell. *Proc. IRE*, Jan., 1957, pp. 55–62. 15 refs. Description of instrumentation for measuring the cumulative distribution of the amplitudes and spacings of pulses in the instantaneous envelope of the atmospheric noise field strength.

Pencil and Paper Calculation of Noise Level in Superheterodyne Radar Receivers. Donald W. Haney. *IRE Trans., ANE Ser.*, Dec., 1956, pp. 157–160. Method for determining the r.m.s. noise level from the output of a second detector as a function of receiver input for any common type of second detector, even though its response is not exactly quadratic.

Survey of Mechanical Filters and Their Applications. J. C. Hathaway and D. F. Babcock. *Proc. IRE*, Jan., 1957, pp. 5–16. 26 refs. Review outlining characteristics and applications of three types of mechanical filters: the ladder-type with resonant plates interconnected by fine wires, the cylindrical rod structure machined to produce alternate necks and slugs, and a cylindrical arrangement with disc resonators interconnected by coupling wires.

Oscillators & Signal Generators

Über das *Grammel*sche Verfahren bei Eigenschwingungsaufgaben. K. Zoller. *Ing.-Arch.*, No. 6, 1956, pp. 401–411. 10 refs. In German. Application of Grammel's equations to the case of a one-dimensional oscillating body. The analysis is used to study the torsional vibration of beams and the bending oscillations of slender rods.

Power Supplies

Reference Generator for SSB Systems. M. I. Jacob. *Electronics*, Feb. 1, 1957, pp. 152–155. Description of a stable frequency generator employing phase-locked oscillators to provide accurate reference frequencies for a single sideband generator.

Radar

Radar Terrain Return at Near-Vertical Incidence. R. K. Moore and C. S. Williams, Jr. *Proc. IRE*, Feb., 1957, pp. 228–238. Test results which indicate that, with occasional exceptions, radar return from the ground is largely due to area scatter, even at angles of incidence near the vertical.

On the Mechanisms of Radar Sea Clutter. Martin Katzin. *Proc. IRE*, Jan., 1957, pp. 44–54. 19 refs. Discussion of experimental data on radar sea clutter with reference to the physical principles involved.

Semiconductors

A Note on the Extended Theory of the Junction Transistor. Toshio Misawa. *J. Phys. Soc. Japan*, July, 1956, pp. 728–739. 22 refs.

The Junction Transistor as a Computing Element. II. E. Wolfendale, L. P. Morgan, and W. L. Stephenson. *Electronic Eng.*, Feb., 1957, pp. 83–87.

Transistor Pulse Generator. F. Rozner. *Elec. & Radio Engr.*, Jan., 1957, pp. 8–10. Discussion of the use of p-n-p and n-p-n transistors in combination to generate pulses with short time rises.

A Transistorized Decade Scaler Utilizing Magnetic Memory Cores. Earl E. Waller. *Cook Tech. Rev.*, Dec., 1956. 24 pp. 14 refs.

Surface Leakage Current in Silicon Fused Junction Diodes. M. Cutler and H. M. Bath. *Proc. IRE*, Jan. 1957, pp. 39–43. Investigation of surface leakage currents to determine their effect on device behavior. The forward and reverse current of fused-junction silicon diodes are compared with the predicted equations arising from a simplified model for surface leakage.

Transmission Lines

A Non-Resonant Waveguide Window. A. E. Barrington and J. T. Hyman. (*IEE Paper 2242 R.*) *Proc. IEE, Part B*, Jan., 1957, pp. 35–38. 13 refs. Derivation of a universal design chart from which the window diameter for the matched condition may be read off directly for any free-space wave length and relative permittivity of the dielectric. A window design with broad-band mode transformers is described.

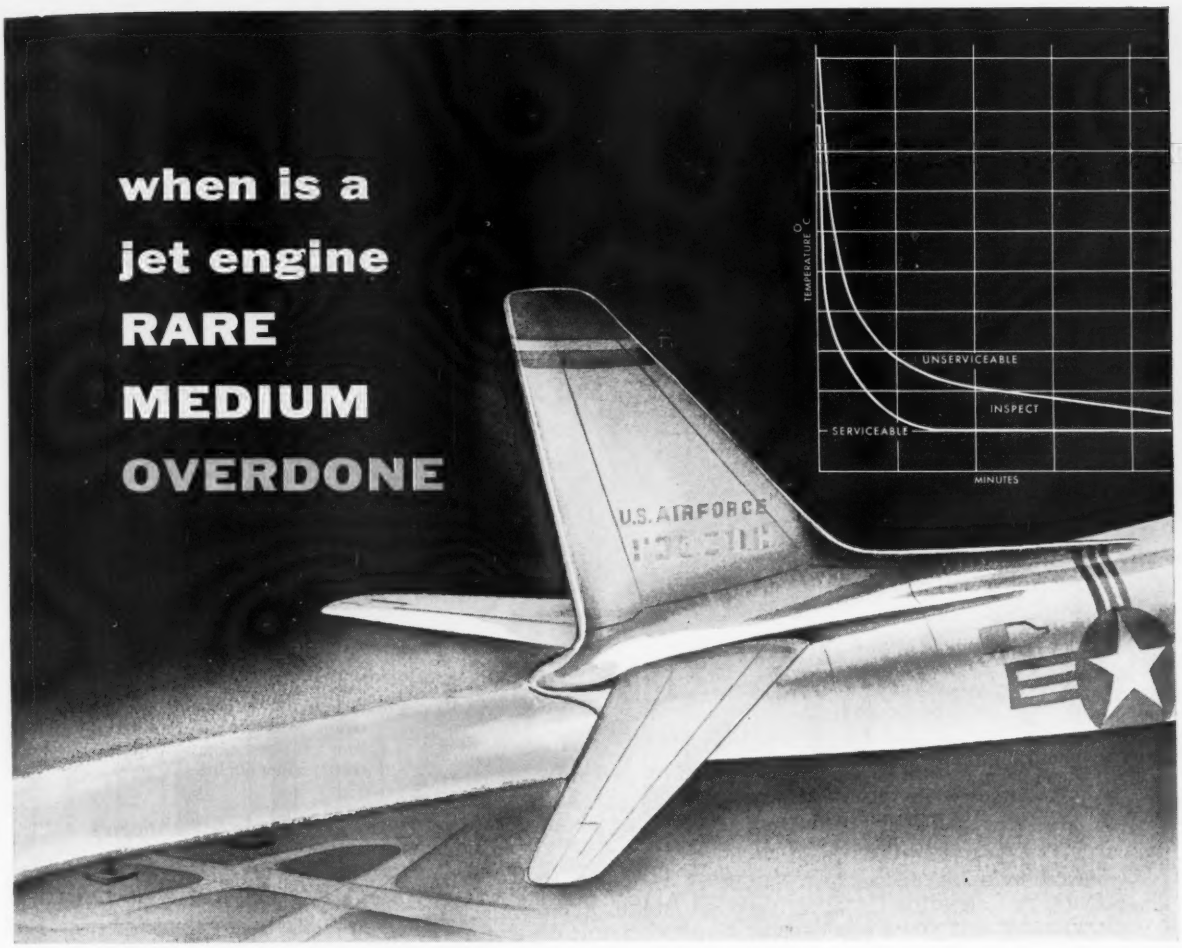
Wave Propagation

Line-Of-Sight Wave Propagation in a Randomly Inhomogeneous Medium. Bob M. Fannin. *IRE Trans., AP Ser.*, Oct., 1956, pp. 661–665. USAF-sponsored calculation of such statistical quantities as the variance, correlation function, and power spectrum for the phase and relative amplitude of the field at a point and their differences between two points.

Equipment

Hydraulic & Pneumatic

Special Issue: Air and Oil Circuit Guide. *Appl. Hydraulics*, Jan., 1957, pp. 181–212. Contents: Component Symbols; Pump Unloading Circuits; Filter Circuits; Pressure Control Circuits; Speed Control Circuits; Pilot-Operated



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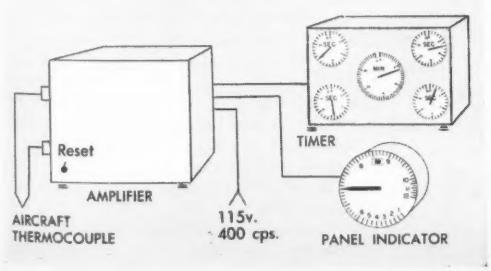

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Flight Operating Problems

The Airline Pilot's Concept of Transport Performance Requirements. L. Homer Mouden. *IAS 25th Annual Meeting, New York, Jan. 28–31, 1957, Preprint 696.* 8 pp. Members, $0.35; nonmembers, $0.75.

Flight Testing

Flight Test Instrumentation. Cecil C. Pine. *Sperry Eng. Rev.*, Nov.-Dec., 1956, pp. 23–27. Discussion of Sperry's development in photographic and graphic recording systems, with comment on the automation program.

Production Test Flying Today. *The Aeroplane*, Jan. 4, 1957, pp. 22–25.

Understanding and Interpreting Pilot Opinion. George E. Cooper. (*IAS 25th Annual Meeting, New York, Jan. 28–31, 1957.*) *Aero. Eng. Rev.*, Mar., 1957, pp. 47–51, 56. Discussion of various approaches that have been used in an attempt to assure the validity and consistency of a test pilot's opinions on an aircraft's flying qualities.

Fuels & Lubricants

Evaporation of Fuel Sprays. II—Experimental Work. G. W. Benson and R. J. Brisebois. *Canada, NAE LR 182,* Nov. 22, 1956. 19 pp. 24 refs. Development of a new technique for measuring the rate of evaporation in a spray, based on the cooling produced when a spray evaporates adiabatically.

Friction, Wear, and Surface Damage of Metals as Affected by Solid Surface Films, Appendix A—**Adhesion Theory of Friction.** Appendix B—**Film Preparation.** Edmond E. Bisson, Robert L. Johnson, Max A. Swikert, and Douglas Godfrey. *U.S., NACA Rep. 1254,* 1956. 19 pp. 48 refs. Supt. of Doc., Wash., $0.25. Results of theoretical and experimental investigations conducted over an 8-year period.

The Use of an Automatic Viscometer for the Study of Lubricant Flow. R. N. Weltmann and P. W. Kuhns. *Lubrication Eng.*, Jan., 1957, pp. 43–50. 18 refs. Theoretical and experimental investigation of flow curves for non-Newtonian, time-dependent materials.

Modern Developments in Solid Propellant Rocket Engineering. Richard D. Geckler and Robert E. Davis. *IAS 25th Annual Meeting, New York, Jan. 28–31, 1957, Preprint 719.* 15 pp. Members, $0.50; nonmembers, $0.85. Discussion of design optimization both by increasing propellant specific impulse and by increasing propellant weight fraction. Includes consideration of environmental testing, especially temperature cycling, as applied to propellant grain design.

Material Compatibility with Gaseous Fluorine. Harold G. Price, Jr., and How-

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ard W. Douglass. *U.S., NACA RM E56K21*, Jan. 23, 1957. 5 pp. Static tests on various materials at pressures from zero to 1,500 psig and atmospheric temperature. Several materials are found compatible at atmospheric pressure, but only Teflon and aluminum oxide are compatible at 1,500 psig.

Instruments

Recent Research on Flat Diaphragms and Circular Plates With Particular Reference to Instrument Applications. A. M. Wahl. (*ASME Diamond Jubilee Annual Meeting, Chicago, Nov. 13–18, 1955, Paper.*). *Trans. ASME*, Jan., 1957, pp. 83–87; Discussion, p. 87; Author's closure, p. 87. 48 refs.

Recording Instruments Aid Research Involving Measurement of Dynamic Phenomena. John L. Harned. *GM Eng. J.*, Jan.-Feb.-Mar., 1957, pp. 18–23. Survey of five types of recorder used for dynamic measurement.

Elevated Temperature Requirements for a New Air-Borne Flight Analyzer. Christian J. Van Der Maas. *Aero. Eng. Rev.*, Mar., 1957, pp. 37–41. Discussion of the need for a flight analyzer capable of uninterrupted operation during the complete ground-to-air cycle, and which will provide continuous and simultaneous time histories of the accelerations, static pressure, total head pressure, and stagnation temperature.

Rotating Electrometer for Comparative Work Function Measurements. H. H. Kolm. *Rev. Sci. Instr.*, Dec., 1956, pp. 1,046–1,048. USAF-Army-Navy-supported research.

Automatic Control

Postroenie Signalov Teleupravleniia s Kombinirovannym Ispol'zovaniem Impul'snykh Priznakov. M. A. Gavrilov. *Avtomatika i Telemekhanika*, Dec., 1956, pp. 1,092–1,113. In Russian. Analysis of the theory of construction of telecontrol signals in combination with pulse indications.

Issledovanie Ustanovivshikhsia Protsessov v Impul'snykh Slediashchikh Sistemakh. Ia. Z. Tsipkin. *Avtomatika i Telemekhanika*, Dec., 1956, pp. 1,057–1,069. 10 refs. In Russian. Derivation of an expression for the steady-state error of pulse systems. Methods for calculating the error coefficients are described, and the steady-state process in plane pulse servosystems is analyzed.

Flight Instruments

Flight Instrument Layouts. M. W. Broom. *The Log*, Jan., 1957, pp. 18–23. Discussion of the need for a basic instrument arrangement and the necessary composition of such an arrangement.

Integrated Instrument System. C. F. Fragola and C. J. Hecker. *IRE Trans., ANE Ser.*, Dec., 1956, pp. 141–144. Historical discussion of the development of flight instrumentation. The present trend toward combining symbolic and pictorial approaches to provide ideal flight instrumentation is explained, and the features of a production system incorporating these concepts are described.

Flow Measuring Devices

A Device for Calibration of Anemometers for Air Flow of Low Velocities. Yoshiro Omori. *J. Phys. Soc. Japan*, Nov., 1956, pp. 1,191–1,200.

A Linear, Temperature Compensated Hot-Wire Anemometer. E. L. Deacon and D. R. Samuel. *J. Sci. Instr.*, Jan., 1957, pp. 24–26. Description of a device which gives a linear output over the range of wind speed from 1 to 16 miles/sec., eliminates the effects of both rapid and slow air-temperature fluctuations, and is suitable for atmospheric - turbulence studies.

The Hot-Wire Anemometer for Turbulence Measurements. I, II, III, IV. B. Wise, D. R. Stewart, and D. L. Schultz. *Gt. Brit., ARC CP 273; CP 274; CP 275; CP 276* (Feb. 10, Sept. 25, 1951; Mar. 24, Apr. 15, 1954), 1956. 11; 15; 71; 39 pp. 25 refs. BIS, New York, $0.45; $0.45; $1.71; $1.08. Development of a hot-wire anemometer to measure turbulence at high air speeds, using radio-frequency and direct-current heating. An analysis of feedback systems is given, and measurements are shown for both turbulence level and spectra at subsonic and supersonic speeds.

Gyroscopes

Der kardanisch gelagerte schnelle symmetrische Kreisel mit Lagerreibung. R. Grammel and H. Ziegler. *Ing.-Arch.*, No. 6, 1956, pp. 351–372. In German. Mathematical examination of the effect of bearing friction in the cardan-mounted rapid symmetrical gyro.

Pressure Measuring Devices

Design of Corrugated Diaphragms. J. A. Haringx. (*ASME Diamond Jubilee Annual Meeting, Chicago, Nov. 13–18, 1955, Paper.*) *Trans. ASME*, Jan., 1957, pp. 55–61; Discussion, pp. 61, 62; Author's closure, pp. 62–64. Description of a straightforward design method based on a few simplifying restrictions.

Investigations of the Properties of Corrugated Diaphragms. W. A. Wildhack, R. F. Dressler, and E. C. Lloyd. (*ASME Diamond Jubilee Annual Meeting, Chicago, Nov. 13–18, 1955, Paper.*) *Trans. ASME*, Jan., 1957, pp. 65–81; Discussion, pp. 81, 82; Author's closure, p. 82. 19 refs. ARDC-NACA-supported correlation of the pressure-deflection characteristics by methods of dimensional analysis. Theoretical and experimental study results in a method for solving a system of linear shell equations derived for combined bending and stretching effects. The system contains lateral loading terms for rotationally symmetrical shells in appropriate independent and dependent variations suitable for complicated meridial shapes and boundary conditions associated with practical diaphragm applications.

Stress & Strain Measuring Devices

Constant Stress Creep Apparatus. Raymond C. Boettner and W. D. Robertson. *Rev. Sci. Instr.*, Dec., 1956, pp. 1,039, 1,040. Description of an apparatus for approximating constant stress in tensile specimens of large cross sections where large applied loads are required.

Magnetostrictive Electricity in Strain Gauges. Irwin Vigness. *Rev. Sci. Instr.*, Dec., 1956, pp. 1,012–1,014. Method to calculate the electric potential induced in ferromagnetic wires when subjected to changes in elastic strain.

Capacitance Pickup Measures Small Forces. John Dimeff and Thomas B. Fryer. *Electronics*, Feb. 1, 1957, pp. 143–145. Development of a resistance-potentiometer element suspended as a pendulum. Undesirable effects of wiper friction are eliminated by moving the contactor slightly away from the resistance element. Electrical correction is maintained by electrostatic coupling.

Vibration Measuring Devices

Electrodynamic Standards for Vibration Pickups. *Tech. News Bul.*, Jan., 1957, pp. 11–14. Description of a calibrator standardization method which is based on an improved mathematical analysis of the problem (i.e., a more comprehensive reciprocity theory), avoids all direct measurement of the vibratory motion itself, and is applicable above as well as below certain resonances in the calibrator.

Laws & Regulations

Grand Canyon, Warsaw and the Hague Protocol. G. Nathan Calkins. *J. Air Law & Commerce*, Summer, 1956, pp. 253–271. Discussion of aircraft accident liability as in the case of the Grand Canyon accident, with reference to the Warsaw Convention as modified by the Hague protocol.

Ratification of the Hague Protocol; Its Relation to the Uniform International Air Carrier Liability Law Achieved by the Warsaw Convention. Paul Reiber. *J. Air Law & Commerce*, Summer, 1956, pp. 272–286.

Machine Elements

Bearings

Cage Design Is Critical for High Speed Ball Bearings. Heinz Hanau. *Av. Age*, Feb., 1957, pp. 52–57 ff.

Design Study of a Hydrostatic Gas Bearing with Inherent Orifice Compensation. S. K. Grinnell and H. H. Richardson. (*ASME Diamond Jubilee Annual Meeting, Chicago, Nov. 13–18, 1955, Paper.*) *Trans. ASME*, Jan., 1957, pp. 11–21. 49 refs.

Gears & Cams

Epicyclic Gears for Control Mechanisms. J. W. Edgemond, Jr. *Prod. Eng.*, Feb., 1957, pp. 194–198. Description of the arrangement of epicyclic gear trains for control, counting, and other light-duty, high-reduction mechanisms.

How Profile Errors Affect Cam Dynamics. Ray C. Johnson. *Mach. Des.*, Feb. 7, 1957, pp. 105–108. Method for predicting the influence of dimensional variations upon velocity and acceleration.

Seals

O-Rings and Interference Seals for Static Applications. James B. Morrison. *Mach. Des.*, Feb. 7, 1957, pp. 91–94. Discussion giving a complete mathemati-

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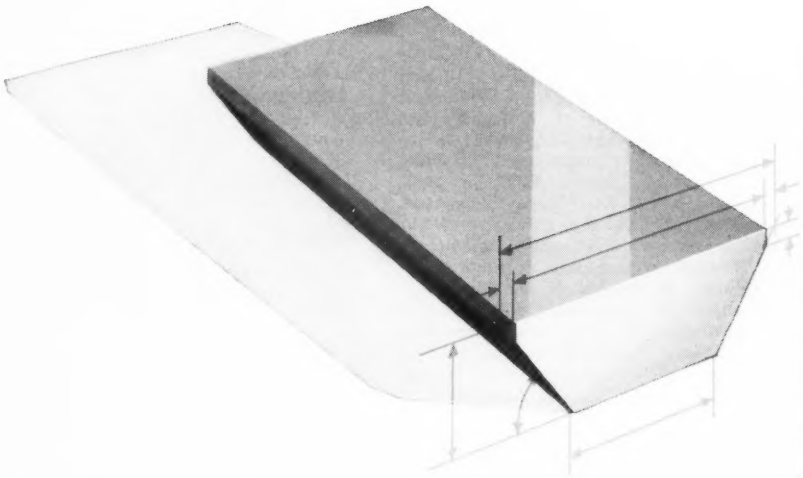

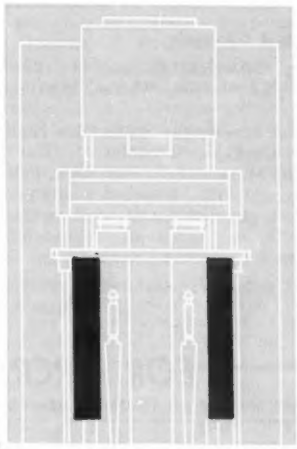

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cal analysis of interference seals and recommended design formulas.

O-Ring Packing Leakage. Ralph E. Middleton. *Lockheed Field Serv. Dig.*, Jan.-Feb., 1957, pp. 10–15. Discussion of the development of seals and back-up rings for aircraft hydraulic systems, and of methods of evaluating leaks around O-rings.

Maintenance

Britannia Maintenance Dock. *Esso Air World*, Nov.-Dec., 1956, pp. 74–77. Description of dock installation to provide faster and more efficient maintenance for both Mk. 102 and Mk. 312 Britannia aircraft.

Special Inspection Procedures Following Hard Landings; Overweight Landings; Flight Through Turbulent Air. *Douglas Serv.*, Jan.-Feb., 1957, pp. 1–8.

Materials

Ceramics & Ceramals

Flame Ceramics. Samuel W. Bradstreet. *The Frontier*, Winter, 1956, pp. 4–7.

Ceramic Investment Shells Give High-Quality Castings. Nicholas J. Grant and Philip Manganaro. *Tool Engr.*, Feb., 1957, pp. 109–113. Description of a program for improving the Glascast process.

Corrosion & Protective Coatings

Hard Coatings and Surfaces for Metals. Robert J. Fabian. *Materials & Methods*, Jan., 1957, pp. 121–140. 29 refs. Survey of the major types of hard coating and surface that can be used in the design of metal products. Each type of surface in terms of its hardness, thickness, wear and corrosion properties, advantages and limitations, and the metals for which it is applicable.

Effect of Ceramic Coatings on Creep of Alloys. *Tech. News Bul.*, Jan., 1957, pp. 6, 7.

Metals & Alloys

A Dictionary of Metallurgy. LI—Vi-We. A. D. Merriman and J. S. Bowden. *Metal Treatment*, Jan., 1957, pp. 21–28.

Fusible Alloys Aid Production. *The Aeroplane*, Jan. 25, 1957, pp. 122 123. Discussion of the advantages of Cerrobend for tube bending, Cerromatrix and Cerrotru for locking assembly jigs after alignment, and Cerrocast for pattern making, cavity proof casting, and thermoelastic molds.

Certain Departures from Plastic Ideality at Small Strains. Appendix—Details of Testing Technique. H. A. Lequear and J. D. Lubahn. (*ASME Diamond Jubilee Annual Meeting, Chicago, Nov. 13–18, 1955, Paper.*) *Trans. ASME*, Jan. 1957, pp. 97–110. 20 refs. Room-temperature experiments involving strains up to about 1 per cent, performed on OFHC copper.

Propriétés de Fluage à Haute Température de l'Onéral M 47, Alliage Réfractaire de Fonderie. H. Bibring and J. Poulignier. *La Recherche Aéronautique*, Nov.-Dec., 1956, pp. 49–54. In French. Study of high-temperature creep properties of Oneral M47 refractory casting alloy.

The Spring Back of Metals. F. J. Gardiner. (*ASME Diamond Jubilee Annual Meeting, Chicago, Nov. 13–18, 1955, Paper.*) *Trans. ASME*, Jan. 1957, pp. 1–7; Discussion, pp. 7, 8; Author's closure, pp. 8, 9. Generalized and simplified mathematical analysis and derivation of a spring-back correction curve for pure bending. An optimum empirical curve is plotted which is based on a qualitative explanation of the departure of extensive test data from the theoretical curve and which shows a band of most probable values. A method for using the general spring-back curve is described, and a worked example is given.

Creep Damage in a Cr-Mo-V Steel as Measured by Retained Stress Rupture Properties. M. H. Jones, D. P. Newman, and W. F. Brown, Jr. (*ASME Diamond Jubilee Annual Meeting, Chicago, Nov. 13–18, 1955, Paper.*) *Trans. ASME*, Jan., 1957, pp. 117–125; Discussion, p. 125; Author's closure, pp. 125, 126. 15 refs.

High Temperature Oxidation Characteristics of Some Manganese-Aluminium Steels. II. Ved Prakash and A. A. Krishnan. *J Sci. & Ind. Res., Sect. B*, Oct., 1956, pp. 600–607. 10 refs. Results of tests for duration varying from 500 to 2,000 hours, at temperatures of 600°, 700°, and 800°C. As the oxidation temperature increases, the high manganese steels show a marked deterioration in their oxidation resistance, whereas low manganese steels exhibit an improvement.

Welding Precipitation-Hardening Stainless Steels. George E. Linnert. *Welding*

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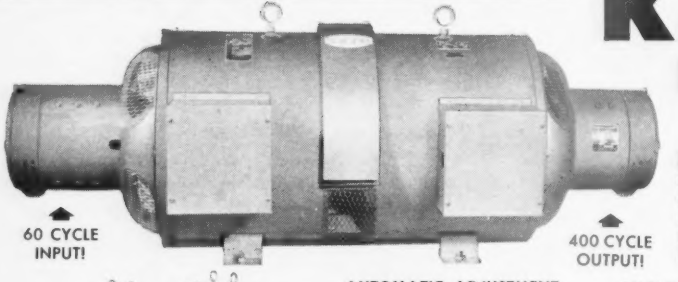

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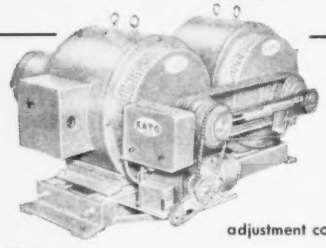
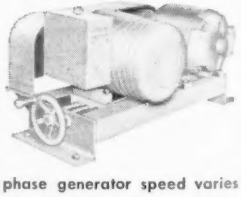


Fully automatic variable frequency motor generator set adjusts 360 to 400 CPS.

Generator mounted controls include reset buttons, limit switch. Motor and Generator remain stationary. Vari-drive pulley adjustment controlled by small motor.

VARIABLE OR FIXED FREQUENCIES RANGING FROM 25 TO 1200 CYCLES. 60 CYCLE LINE UP TO 500 KVA

MANUAL ADJUSTMENT
MODEL 28XA08



Easily adjusted by simple hand wheel, controlling variable pitch pulley V-belt arrangement. This motor generator set gives 45 to 60 CPS output. Unit holds speed accurately. Frequency meter on generator panel indicates output. Single phase generator speed varies from 1350 to 1950 RPM.

MAGNETIC AMPLIFIER AUTOMATIC VOLTAGE REGULATOR

Synchroncus motor starter and generator controls including magnetic amplifier voltage regulator in cabinet.

REMOTE CONTROL

Remote control frequency adjustment varies speed from 1080 to 1320 RPM., thus varying frequency. Bench mock-up test stations may be located anywhere.

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J., Jan., 1957, pp. 9–27. 11 refs. Discussion of four types of stainless steel, classified according to their microstructures in the hardened condition. Details on weldability, heat-treatment, and welding procedures are presented.

Metals & Alloys, Nonferrous

Investigation of the NiAl Phase of Nickel-Aluminum Alloys. Edward M. Grala. *U.S., NACA TN 3828*, Jan., 1957. 33 pp. 10 refs. Investigation to determine the effects of composition and homogenization heat-treatments on hardness and tensile properties of cast alloys of the NiAl intermetallic phase.

A Critical Review of the Mechanism of Ageing in Alloys Based on the Aluminium-Zinc-Magnesium System. I. J. Polmear. *Australia, Aero. Res. Comm. Rep. ACA-59*, Aug., 1955. 22 pp. 74 refs.

Residual Stresses in Cold Extruded Aluminum. J. Frisch and E. G. Thomsen. (*ASME Diamond Jubilee Annual Meeting, Chicago, Nov. 13–18, 1955, Paper.*) *Trans. ASME*, Jan., 1957, pp. 155–158; Discussion, pp. 159, 160; Author's closure, p. 160. 10 refs. Experimental investigation of a 1.5-in.-diameter bar extruded at room temperature from an 1100-0 (2S-O) aluminum 4.3-in.-diameter billet.

Selection of Aluminium Alloys by Fatigue Properties. R. G. Ward. *Aircraft Eng.*, Jan., 1957, pp. 19, 20. Method for comparing the performance of different alloy types under fatigue conditions for which complete data are not available.

Some Creep Properties of Annealed Ti 150A at Room Temperature and 350°C. L. W. Larke. *Gt. Brit., RAE TN Met. 249*, Aug., 1956. 12 pp. Test results for constant-load tensile creep in the range of 0.1 per cent to 1.0 per cent total plastic strain for durations up to 1,000 hours.

Effect of Surface Finish on the Fatigue Strength of Titanium Alloys RC 130B and Ti 140A. G. M. Sinclair, H. T. Corten, and T. J. Dolan. (*ASME Diamond Jubilee Annual Meeting, Chicago, Nov. 13–18, 1955, Paper.*) *Trans. ASME*, Jan., 1957, pp. 89–95; Discussion, pp. 95, 96; Author's closure, p. 96. Experimental investigation with evaluation of the resulting data carried out in terms of a first approximation derived for the relationship between hardness, surface roughness, and fatigue strength.

Oxygen Cutting Titanium and Titanium Alloys. G. Coates. *The Engr.*, Jan. 25, 1957, pp. 132–134. Method employing a stream of high-purity oxygen to cut titanium. Discussion includes the influence of alloying elements, comparison of costs with other cutting methods, and possible applications.

Technical Data for the Aeronautical Buyer About Titanium. Frank Vandenburgh. *Aero. Purchasing*, Jan., 1957, pp. 39–41, 80.

Nonmetallic Materials

Das Verhalten von Kunststoffen bei Drehbeanspruchung. F. Beér. *VDI Zeitschrift*, Jan. 1, 1957, pp. 13, 14. In German. Analysis of twist and tensile properties of plastics.

Comparison of Mechanical Properties of Flat Sheets, Molded Shapes, and Post-formed Shapes of Cotton-Fabric Phenolic Laminates. F. W. Reinhart, C. L. Good, P. S. Turner, and I. Wolock. *U.S., NACA TN 3825*, Jan., 1957. 60 pp. 22 refs.

Mathematics

Remarks on a Uniqueness Theorem for Closed Surfaces. Philip Hartman. *Johns Hopkins U., Dept. Math., TR 3 (AFOSR TN 56–589)[AD 115016]*, Dec., 1956. 8 pp. Application of a maximum principle for a singular elliptic partial differential equation to obtain versions of the theorems of Voss dealing with closed surfaces in Euclidean 3-space without his assumptions of analyticity.

Sur le Calcul par Itération des Modes Propres d'Ordre Supérieur. D. Clerc. *La Recherche Aéronautique*, Nov.-Dec., 1956, pp. 39–48. In French. Extension of the Duncan and Collar reduced-matrix method in order to permit control of the degree of accuracy at any stage of the calculation.

Some Conditional Probability Distribution Functions. Glen E. Baxter. *U. Minn. TR 1 (AFOSR TN 56–483) [AD 97367]*, Oct. 1, 1956. 17 pp.

A New Method of Inversion of the Laplace Transform. Athanasios Papoulis. *Quart. Appl. Math.*, Jan., 1957, pp. 405–414.

A New Method for Factoring Higher Order Polynomials. Raymond Rapacz. *Sperry Eng. Rev.*, Nov.-Dec., 1956, pp. 13–17.

Uniqueness of Mapping Pairs for Elliptic Equations. R. M. McLeod, J. J. Gergen, and F. G. Dressel. *Duke U. Rep. (AFOSR TN 56–554) [AD 110373]*, Oct., 1956. 15 pp. 16 refs. Extension of the Riemann problem to the determination of generalized mapping pairs for a prescribed elliptic system.

On the Continuous Solution of Integral Equations by an Electronic Analogue. I. Michael E. Fisher. *Proc. Cambridge Philos. Soc.*, Jan., 1957, pp. 162–174. 15 refs. Scheme for solving a class of integral equations in times as short as 0.1 sec. by means of a high-speed analog-function store developed to carry out a special iterative procedure shown to be more efficient than the classical Neumann process. Consideration is given to the problem of the kernel generation at high repetition rates, and a method based on pivotal function generators is described. Includes analysis of likely errors.

Non Locally Connected Spaces Related to Absolute Neighborhood Retracts and Fixed Point Properties. D. G. Bourgin. *U. Ill. Rep. (AFOSR TN 56–578) [AD 110400]*, Jan. 30, 1957. 10 pp.

The Topology of Almost Uniform Convergence. John W. Brace. *U. Md. Dept. Math. Rep. (AFOSR TN 56–595) [AD 115022]*, Dec., 1956. 28 pp. 19 refs. Method using quasi-uniform convergence for topologizing function spaces.

A Sequential Multiple Decision Procedure for Selecting the Best One of Several Normal Populations with a Common Unknown Variance, and Its Use with Various Experimental Designs. Robert E. Bechhofer. *Cornell U. Mech. Eng. Rep. 10 (AFOSR TN 56–551) [AD 110370]*, Nov., 1956. 21 pp. 21 refs.

On the Error of the Finite Difference Method in 1-Dimensional Boundary Value Problems. Hiroshi Fujita. *J. Phys. Soc. Japan*, Feb., 1956, pp. 160–169.

Integration of a Differential Form on an Analytic Complex Subvariety. Pierre Lelong. *Inst. Advanced Study, Princeton, N.J., Rep. (AFOSR TN 57–20)[AD 115054]*, Dec., 1956. 6 pp.

A Stability Theorem for Solutions of Abstract Differential Equations, and Its Application to the Study of the Local Behavior of Solutions of Elliptic Equations. P. D. Lax. *Commun. on Pure & Appl. Math.*, Nov., 1956, pp. 747–766. 22 refs. ONR-supported analysis.

Ein Verfahren zur Stabilitätsfrage bei Matrizen-Eigenwertproblemen. Hans-Rudolf Schwarz. *ZAMP*, Nov. 25, 1956, pp. 473–500. 10 refs. In German. Description of a method for solving, without evaluating the characteristic polynomial, the problem $(A-\lambda E)x = 0$ for real or complex matrices A, when λ is the number of eigenvalues with positive real parts.

Otsenka Reshenii Nekotorych Nelineinykh Differentsial'nykh Uravnenii v Oblasti Asimptoticheskoi Ustoichivosti. D. A. Dobrotin. *Prikl. Mat. i Mekh.*, 1956, pp. 723–732. In Russian. Evaluation of methods for solving nonlinear differential equations in the case of asymptotic stability.

The Numerical Solution of Linear Differential Equations in Chebyshev Series. C. W. Clenshaw. *Proc. Cambridge Philos. Soc.*, Jan., 1957, pp. 134–149. Description of a method for computing the coefficients in the Chebyshev expansion of a solution of an ordinary linear differential equation when the solution required is bounded and possesses a finite number of maxima and minima in the finite range of integration. Comparison is made with the Dennis-Poots Fourier-series method and with Lanczos' polynomial-approximation procedure. Includes illustrative examples of the present method's use in some first- and second-order equations—among them, one eigenvalue problem.

Formal Powers and Power Series. Lipman Bers. (*Cen. Natl. Rech. Sci., Colloque Internatl. No. 71, Nancy, Apr., 1956, Paper.*) *Commun. on Pure & Appl. Math.*, Nov., 1956, pp. 693–711. 14 refs. OOR-supported presentation of Bers' previous results of the theory of pseudo-analytic functions, under essentially minimal smoothness conditions, and continuation of the development of that theory by considering questions in the large. Pseudoanalytic formal powers are constructed, their properties are investigated, and some expansion theorems are proved.

Application of Hilbert Space Methods to Lie Groups Acting on a Differentiable Manifold. Jacqueline Lelong-Ferrand. *Inst. Advanced Study, Princeton, N.J., Rep. (AFOSR TN 57-14)[AD 115046]*, Dec., 1956. 6 pp.

Multiple Range Tests for Correlated and Heteroscedastic Means. David B. Duncan. *N.C. U., Inst. Statistics, MS 161 (AFOSR TN 56-597)[AD 115024]*, Dec., 1956. 17 pp. 10 refs. Presentation of a more complete method than heretofore developed for extensions due to

Kramer, Bleicher, and Sanders. Analysis also indicates the closeness of these complete tests of heteroscedastic and correlated means to those of the corresponding test of homoscedastic and uncorrelated means and outlines a short-cut skipping principle useful in applying multiple-range tests to a large number of treatment means (or totals).

Mechanics

On Uniform Acceleration in Special and General Relativity. L. Marder. *Proc. Cambridge Philos. Soc.*, Jan., 1957, pp. 194–198. Consideration of two definitions of uniform acceleration in relativity theory, with particular reference to their physical realizations.

Nekotorye Zadachi Diffraktsii Ploskikh Uprugikh Voln. A. F. Filippov. *Prikl. Mat. i Mekh.*, 1956, pp. 688–703. 13 refs. In Russian. The problems of diffraction of plane elastic waves are studied, and asymptotic formulas for the solution of such problems are derived.

Meteorology

The International Geophysical Year 1957–58; Fourth Session of GSAGI. *WMO Bul.*, Jan., 1957, pp. 31–33. Discussion of some meteorological resolutions, adopted by the Special Committee for the IGY at Barcelona (Sept. 10–15, 1956), which relate to periodic comparisons of instruments, upper-air networks, measurements of atmospheric chemical content, IGY world data centers, instrument recovery, and nuclear radiation in the atmosphere.

The Height Variation of Upper Atmospheric Winds. J. S. Greenhow and E. L. Neufeld. *Philos. Mag., 8th Ser.*, Dec., 1956, pp. 1,157–1,171. 13 refs. Investigation using the radio echo meter technique to determine the variation of wind velocity with altitude in the 80–100 km. region.

Military Aviation & Armament

Integration of the F-100 Airplane Into Air Force Squadron Service. Maurice G. Long. *SAE Annual Meeting, Detroit, Jan. 14–18, 1957, Preprint 51.* 5 pp.

Missiles

The Guided Missile As a Systems Engineering Problem. Simon Ramo. (*IAS-CAI Internatl. Meeting, Toronto, Nov. 26, 1956.*) *Can. Aero. J.*, Jan., 1957, pp. 3–9.

Oerlikon Rockets. Maurice F. Allward. *Spaceflight*, Jan., 1957, pp. 64–70. Discussion of the two types of rocket and a surface-to-air missile manufactured by Oerlikon, Switzerland.

Flight Investigation of a Roll-Stabilized Missile Configuration at Varying Angles of Attack at Mach Numbers Between 0.8 and 1.79. Jacob Zarovsky and Robert A. Gardiner. *U.S., NACA TN 3915*, Jan., 1957. 36 pp. Results of flight tests which indicate that satisfactory roll stabilization may be obtained from the combination of wing-tip ailerons and the gyro-actuated automatic-control system during changes in angle of attack and roll trim at supersonic and transonic speeds.

Navigation

A Comparison of Anti-Collision Lights. R. A. Stone. *Air Line Pilot*, Feb., 1957, pp. 2–4. Investigation based on flight tests of flash-tube anticollision lights and incandescent lights.

Electronic Aids

Operational Need and Use for Self-Contained Navigation Systems. Robert W. West. *IAS 25th Annual Meeting, New York, Jan. 28–31, 1957, Preprint 695.* 6 pp. Members, $0.35; nonmembers, $0.75. Discussion of navigational characteristics required for current military aircraft including (a) tactical or fighter types, (b) strategic bomber and reconnaissance aircraft, and (c) guided missiles.

Doppler Navigation. William J. Tull. *IAS 25th Annual Meeting, New York, Jan. 28–31, 1957, Preprint 681.* 11 pp. Members, $0.35; nonmembers, $0.75. Discussion of a new technique for measuring ground speed and drift angle without celestial or terrestial assistance. The theoretical principles are outlined, and a description of the operation of the ASN-7 indicator and control panel is given.

New Navigation System Built Around Doppler Radar. James Holahan. *Av. Age*, Feb., 1957, pp. 76–81 ff. Discussion of the physical principles behind Doppler radar navigation which provides continuous position information, and a brief description of the operation of the radar computer equipment.

Decca Navaids. Roy McLeavy. *Air*, Dec., 1956, pp. 29–32. Includes basic layout of the Dectra system, its ranging accuracy, and other operating aspects.

New Raydist DM System Applied to Helicopter Navigation and Traffic Control. Charles E. Hastings and Allen L. Comstock. *AHS J.*, Jan., 1957, pp. 25–29.

Azimuth Errors of the TACAN System. De Witt T. Latimer, Jr. *IRE Trans., ANE Ser.*, Dec., 1956, pp. 150–156. Evaluation of the effects of adding the ninth harmonic to the fundamental bearing signal of the Tacan system in terms of the improved system accuracy, particularly under adverse siting conditions. Includes discussion of azimuth error data, collected in ready-to-use form, which allow separation of the site error from the total system.

A Visual Communication System. V. I. Weihe, B. R. Boymel, and S. C. Feild, Jr. *IRE Trans., ANE Ser.*, Dec., 1956, pp. 145–149. Discussion of the operational requirements of an Air Traffic Control Signaling System. The relative applicability of a number of existing and proposed communication systems are shown by using an arbitrary but consistent rating system.

Inertial Navigation Looks Best for High Speed Planes. Norman F. Parker and Charles P. Greening. (*NATO AGARD Guided Missiles Seminar, Venice, Sept., 1956, Paper.*) *Av. Age*, Feb., 1957, pp. 46–51 ff. Abridged. Discussion of the basic physical elements of inertial navigation, stressing source propagation and the limited magnitude of system errors.

Traffic Control

Air Force Air Traffic Control. S. A. Mundell. *IAS 25th Annual Meeting, New York, Jan. 28–31, 1957, Preprint 722.* 5 pp. Members, $0.35; nonmembers, $0.75. Discussion leading to and explaining four opinions: that there can be only one system for air traffic control for both peacetime and wartime military operation; that there can be only one organization for the control of aircraft and airspace wherever military aircraft fly; that the controlling agency must be a joint one made up at least of the CAA and AACS; and that this agency must be integrated with the Air Defense Command during peacetime to ensure wartime operational continuity.

Airspace Use for Air Traffic Control and Air Defense. D. D. Thomas. *IAS 25th Annual Meeting, New York, Jan. 28–31, 1957, Preprint 670.* 7 pp. Members, $0.35; nonmembers, $0.75. Discussion of the diminishing airspace in terms of the users, current allocation methods, and the problem areas, trends, and future outlook.

Common or Uncommon Systems: Air Traffic Control and Air Defense. David R. Israel and Herbert Sherman. *IAS 25th Annual Meeting, New York, Jan. 28–31, 1957, Preprint 671.* 6 pp. Members, $0.35; nonmembers, $0.75. USAF-Army-Navy-supported discussion describing the basic similarities and differences in the two systems and suggesting the optimum future course of investigations designed to develop a common system.

Common System Standards. Howard K. Morgan. *IAS 25th Annual Meeting, New York, Jan. 28–31, 1957, Preprint 668.* 5 pp. Members, $0.35; nonmembers, $0.75. Discussion of the need for a common system in air traffic control for flight plans, signaling, and surveillance.

Nuclear Energy

Problems of the Nuclear Age. *Hawker Siddeley Rev.*, Dec., 1956, pp. 99–102. Discussion of the materials, reaction, and cooling problems involved in development of nuclear power plants for aircraft.

The Safety Aspects of the Use of Nuclear Energy. C. R. Russell. *SAE Annual Meeting, Detroit, Jan. 14–18, 1957, Preprint 4.* 10 pp. Discussion of the hazards associated with nuclear reactor operation and of means to ensure protection against such hazards.

Effects of Radiation on Materials. Michael Ference, Jr. *SAE Annual Meeting, Detroit, Jan. 14–18, 1957, Preprint 3.* 13 pp. 14 refs. Discussion of the nature of changes that occur in the physical and mechanical properties of materials subjected to various types of radiation.

Physics

The Analytic Invariants of an Area-Preserving Mapping Near a Hyperbolic Fixed Point. Jürgen Moser. *Commun. on Pure & Appl. Math.*, Nov., 1956, pp. 673–692. ONR-sponsored investigation.

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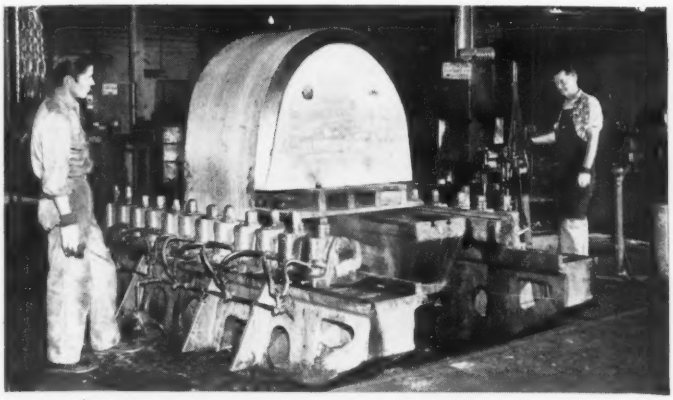

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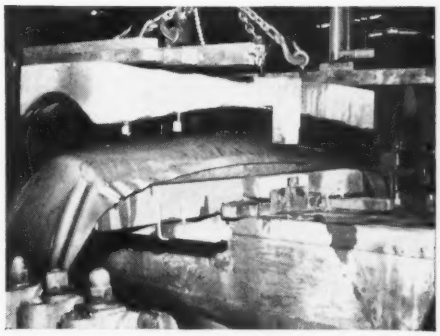

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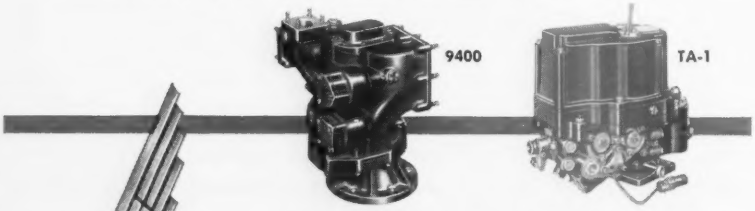

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On Resonance in Infinite Gratings of Cylinders. S. N. Karp and J. Radlow, *IRE Trans., AP Ser.*, Oct., 1956, pp. 654–661. 12 refs. USAF-supported investigation of the behavior of diffraction gratings of cylinders for wave lengths neighboring certain critical wave lengths—the so-called "Rayleigh wave lengths."

Electrostatic Lens. N. P. Carleton, *Rev. Sci. Instr.*, Jan., 1957, pp. 9, 10. USAF-ONR-supported development of an electrostatic lens consisting of a cylindrical surface along which the potential varies as the square of the distance from the original plane. This lens is more efficient in focusing a highly divergent beam of ions than several combinations of conventional lenses.

The Properties of a Gaseous or Liquid Mixture (Preliminary Study). J. O. Hirschfelder and R. J. Buehler. *U. Wis. NRL Dept. Chem. TR WIS-OOR-17*, Jan. 9, 1957. 13 pp. Theoretical investigation in an effort to set up a semi-empirical scheme for using the generalized equations for pure substances to explain the properties of the mixtures.

Power Plants

Jet & Turbine

Gas Turbines in 1956. *The Engr.*, Jan. 4, 1957, pp. 26, 27. Review of British engine development during 1956. Discussion includes turboprops, ram-jets, and by-pass jets.

Belastung und Lebensdauer der Gasturbine. N. Gašparović. *VDI Zeitschrift*, Jan. 1, 1957, pp. 23–25. In German. Discussion of the operation and life expectancy of gas turbines.

Effect of Turbojet Compressor Coolants on Afterburner Combustion. James W. Useller. *Jet Propulsion*, Jan., 1957, pp. 25–27. Discussion to relate the effect to that of water vapor and ammonia on the combustion-propagation mechanism.

The Small Gas Turbine: Problem and Promise. Sumner Alpert. *SAE Annual Meeting, Detroit, Jan. 14–18, 1957, Preprint 30.* 12 pp. Discussion of the operational history of two Solar gas-turbine auxiliary units.

Evolution of a Gas Turbine. Wallace E. Skidmore. *SAE Annual Meeting, Detroit, Jan. 14–18, 1957, Preprint 31.* 22 pp. Discussion of the development of a Boeing small gas turbine in terms of increased power, decreased fuel consumption, and a longer overhaul life.

Some Experiences in the Development and Application of Lycoming's T53 Gas Turbine Engine. Anselm Franz. *SAE Annual Meeting, Detroit, Jan. 14–18, 1957, Preprint 32.* 10 pp. Discussion showing how experience demonstrates the validity of Lycoming's basic design concepts for gas-turbine engines in the low-power range. These concepts are reviewed, and some of the design features are described.

By-Pass Engine for Transport Aircraft. A. C. Lovesey and L. G. Dawson. *IAS 25th Annual Meeting, New York, Jan. 28–31, 1957, Preprint 708.* 10 pp. Members, $0.35; nonmembers, $0.75. Comparison of the jet and by-pass engines assuming the same design techniques, stress levels, and use of similar materials.

It is concluded that the by-pass engine has the advantage in both weight and fuel consumption for transport operations.

The Pattern of Tiny Engines. *The Aeroplane*, Jan. 11, 1957, pp. 52–54. Discussion of the characteristics and applications of the following small jets: Rolls-Royce R.B. 93 and R.B. 108, Westinghouse XJ-81, Fairchild XJ-83, and General Electric XJ-85.

Experimental Stress Analysis in Small Turbines. Gordon Sorenson. *SAE Annual Meeting, Detroit, Jan. 14–18, 1957, Preprint 33.* 19 pp.

Development of the Olympus Powerplant of the Avro Vulcan. *Bristol Quart.*, Autumn, 1956, pp. 77–80. Discussion of the engine which combines the advantages of the highest thrust yet released with the smallest diameter of any British engine of comparable thrust, the lowest fuel consumption, weight comparable to that of other engines in its class, and less altitude fall-off in performance than that of single-shaft engines of the same sea-level thrust.

Choosing an Advanced Turbojet Design. F. H. Keast. (*CAI Annual Gen. Meeting, May, 1956.*) *Av. Age*, Feb., 1957, pp. 36–41 ff. Abridged. Discussion of the effects of various design parameters on engine weight and fuel consumption.

Military Jets Need Adapting for Civilian Transport Use. Abe Silverstein and Newell D. Sanders. *SAE J.*, Jan., 1957, pp. 35–39.

Turboprop Fuel Control Can Tolerate Only Limited Range of Fuel Densities. F. G. Dougherty and M. C. Hardin. (*SAE Metropolitan Section, Mar., 1956, Paper.*) *SAE J.*, Jan., 1957, pp. 40, 41. Abridged.

Wind-Tunnel Technique for Simultaneous Simulation of External Flow Field About Nacelle Inlet and Exit Airstreams at Supersonic Speeds. Gerald W. Englert and Roger W. Luidens. *U.S., NACA TN 3881*, Jan., 1957. 25 pp. Investigation of a technique using high-pressure air piped upstream through a simulated jet to the exhaust nozzle of the engine. It is then discharged through perforations in the pipe or in a downstream direction through a target-type reverser at the end of the pipe.

Rolls-Royce Reheat Developments. I. *The Aeroplane*, Jan. 25, 1957, pp. 118–121. Results of Rolls-Royce afterburner experiments discussed in connection with experience on actual reheat systems used by the R-R Avon Engines in the Supermarine Swift and Fairey F.D.2 aircraft.

Ram-Jet & Pulse-Jet

Flight Development of Ramjets; The Basic Importance of Test Vehicles. *Bristol Quart.*, Autumn, 1956, pp. 67–72.

Reciprocating

The Influence of Engine Speed Upon Pre-Ignition. E. M. Goodger. *Coll. of Aeronautics, Cranfield, Note No. 51*, Sept., 1956. 16 pp. 10 refs. Analysis of preignition using published results together with those obtained from a single-cylinder D.V.L. engine by means of the heated wire and ionization gap technique.

Rocket

A Simple Equation for Rapid Estimation of Rocket Nozzle Convective Heat Transfer Coefficients. D. R. Bartz. *Jet Propulsion*, Jan., 1957, pp. 49–51. Army-sponsored research.

Bedeutung und Anwendung der Regelungstechnik für Flüssigkeits-Raketenantriebe. R. H. Reichel. *VDI Zeitschrift*, Jan., 11, 1957, pp. 55–61. 28 refs. In German. Study of the principle and application of mixture ratio control in liquid-propellant rocket engines.

Le Volume Optimum du Réservoir de Gaz pour l'Alimentation des Fusées à Liquides. Pierre Larue. *La Recherche Aéronautique*, Nov.-Dec., 1956, pp. 17–20. In French. Analysis of the problem of optimum volume of a gas reservoir for supplying liquid-propellant rockets. Results are compared with experimental data.

Rocket Engine Reliability. A. G. Thatcher and H. A. Barton. *Ordnance*, Jan.-Feb., 1957, pp. 722–726. Development of a reliability program using statistical methods. Several of these methods are discussed and applied to rocket-engine systems.

Evaluating Propellant Systems. Joseph Irgon. *Missiles & Rockets*, Jan., 1957, pp. 62, 63.

Production

Probleme în Tehnologia Fabricării Avioanelor. M. M. Popescu. *Rev. Transp.*, Nov., 1956, pp. 431–435. In Rumanian. Evaluation of the problems presented by the technology of aircraft production.

Metalworking

Getting Titanium Parts Mass Produced. J. L. LaMarca and J. L. McCabe. *SAE J.*, Nov. 25, 1956, pp. 75–77. Discussion of four major manufacturing problems encountered in the mass production of titanium parts for turbojet engines. The problems include getting acceptable forgings, recovering adequate ductility in forgings by heat treatment, developing machining processes to produce titanium components successfully, and reducing hydrogen content to acceptable levels in semifinished parts.

On the Drilling of Metals. II—The Torque and Thrust in Drilling. M. C. Shaw and C. J. Oxford, Jr. (*ASME Diamond Jubilee Annual Meeting, Chicago, Nov. 13, 1955, Paper.*) *Trans. ASME*, Jan., 1957, pp. 139–147; Discussion, pp. 147, 148; Author's closure, p. 148. Derivation of general drill-torque and thrust equations based on dimensional reasoning and the rules of cutting-force development in two-dimensional cutting.

Investment Casting Bids for Big Role in Jet Engines. Dean K. Hanink. *Av. Age*, Feb., 1957, pp. 94–99 ff.

Steel and Titanium Forgings; Production Considerations, Need for Closer Tolerances, Heavy Cost of Machining. S. R. Carpenter. *Aircraft Prod.*, Feb., 1957, pp. 50–53.

Forged Steel Crankshafts. Harold F. Wood. *SAE Annual Meeting, Detroit, Jan. 14–18, 1957, Preprint 13.* 16 pp. Description of the forging process for steel crankshafts, and discussion of crankshaft design to facilitate forging.

The Present State of Scientific Knowledge in Hot Shaping or Forging. Eric Siebel. *Steel Processing*, Jan., 1957, pp. 19–24. Review of hot-shaping methods along with general rules for shaping in the plastic state. Formulas for these rules are explained according to the properties of the material, temperature, deformation rate, and the degree of shaping.

Tips on Buying Forgings. Samuel A. Forter, Jr. *Aero. Purchasing*, Jan., 1957, pp. 34, 35, 64–67.

Buckling Limits in Contour Forming. I. William W. Wood. *Tool Engr.*, Feb., 1957, pp. 85–91. Theoretical investigation of plate buckling and other types of failure, description of the factors leading to buckling, and discussion of the development of formability indexes for a number of materials commonly used in aircraft design. Includes a table of these indexes.

Contour-Etching; Removing Metal by Controlled Chemical Action. A. W. Sheppard. *Aircraft Prod.*, Feb., 1957, pp. 71–75. Description of the process and of the methods currently in use.

Stepped Extrusions—A New Metal Form. C. J. Hoffman. *Materials & Methods*, Jan., 1957, pp. 101–103. Discussion of the design, mechanical properties, and finishing of aluminum extrusions having two or more different cross sections. Possible future developments in extrusion technology are also cited.

Heat-Treatment of Light Alloys. T. R. G. Williams. *Metal Treatment*, Jan., 1957, pp. 34–38. 16 refs. Discussion of factors governing the choice of equipment and of the thermal practice adopted for heat-treating aluminum and its alloys. Existing furnace designs are compared and possible future trends suggested.

Machining Steel. *Aircraft Prod.*, Feb., 1957, pp. 78–81. Discussion of the development of new grades of tungsten-carbide for machining under current operating conditions.

A Straight-Line Generator as in Use at the Royal Aircraft Establishment for the Machining of Aerofoil Shapes. S. W. Potter. *Gt. Brit., RAE TN A.D.W.3*, Sept., 1956. 6 pp.

Deep Boring; Machining High-Tensile Steels on Standard Machines. W. R. Petts. *Aircraft Prod.*, Feb., 1957, pp. 44–49.

Production Engineering

Designing for Reliability. R. B. Wilson. *Mach. Des.*, Jan. 10, 1957, pp. 140–142, 144. Discussion of reliability factors, taking into account equipment environment, testing, and failure analysis.

Tooling

Issledovanie Skvazhiny pri Turbinnom Sposobe Bureniia kak Ob'ekta Avtomaticheskogo Regulirovaniia. Ia. B. Kadymov. *Avtomatika i Telemekhanika*, Dec., 1956, pp. 1,070–1,080. In Russian. Results of theoretical and experimental investigations of a bore hole at turbine drilling as part of automatic-control research.

Welding

Resistance Welding; Recent Advances in Application to Airframe Construction. N. K. Gardner. *Aircraft Prod.*, Feb.,

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1957, pp. 63–71. 23 refs. Discussion of the procedure with details on the design stage, fatigue strength provided by the machine settings, the welding equipment, output characteristics, control and inspection, quality control and its use, design information, consistency in production, and productivity and costs.

Rotating Wing Aircraft

The Rotary Round Table. *AHS J.*, Jan., 1957, pp. 2–10. Contents: Flight Safety in High Altitude Helicopter Operations, Carl Agar and Ada Carlson. Flight Safety in Helicopter Offshore Operation, L. L. McCombie. Safety in Experimental Helicopter Test Flying, Floyd W. Carlson. Safety in Army Helicopter Training, Bernard Mattson. Helicopter Safety in Naval Operations.

Aerodynamic Aspects of the Unloaded Rotor Convertible Helicopter. Kurt H. Hohenemser. (*Appl. Mech., 9th Internatl. Cong., Brussels, Sept. 5–13, 1956.*) *AHS J.*, Jan., 1957, pp. 47–54. Discussion, based on wind-tunnel tests with a quarter-scale model, of the aerodynamic characteristics of the XV-1 unloaded rotor convertible helicopter (convertiplane) with respect to rotor-speed control in autorotation, lift distribution between rotor and fixed wing, and the characteristics of the floating V-tab-controlled horizontal tail surface.

Reliability Requirements for Helicopter Flight Controls. H. Hecht and L. Kaufman. *IAS 25th Annual Meeting, New York, Jan. 28–31, 1957, Preprint 682.* 7 pp. Members, $0.35; nonmembers, $0.75. Review of some of the specific reliability problems connected with the design and selection of a helicopter flight-control system, and discussion indicating the need for fundamental quantitative work in optimizing such requirements. Some steps of the design procedure using these requirements are outlined.

Saunders Roe Skeeter. *Air Age*, No. 3, 1956, pp. 20–23. Includes description of engine, main and tail rotors, fuel system, undercarriage, and flight controls.

The Rocket Boosted "Skeeter" Helicopter. C. Faulkner. *Saro Prog.*, Winter, 1956, pp. 6–9. Discussion of design philosophy and characteristics of a helicopter using a rocket boost located on rotor tips.

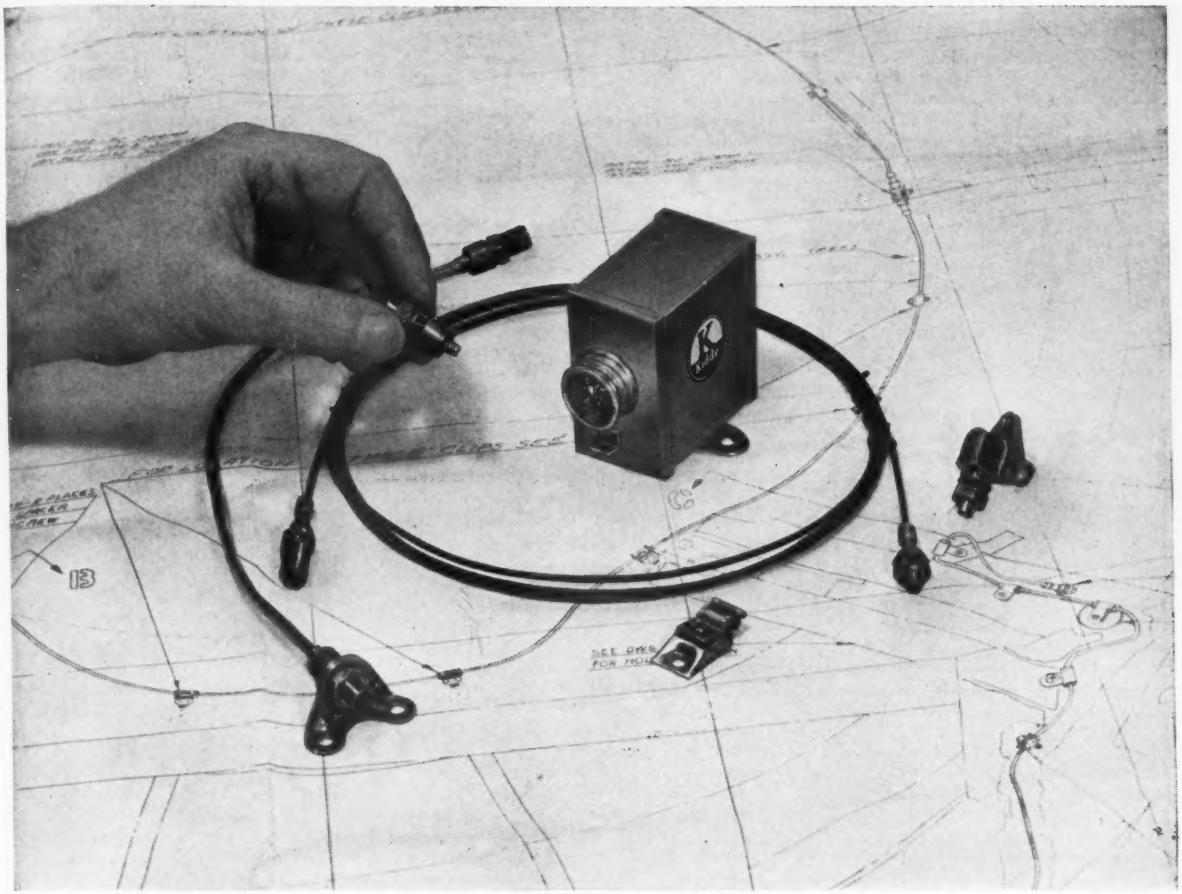
Bristol 192, the R.A.F.'s First Twin-Rotor Helicopter: Design Details and Sketches. *Flight*, Jan. 18, 1957, pp. 69–71.

Cessna's YH-41 Designed for Simplified Maintenance. William Robinson. *AHS Newsletter*, Jan., 1957, pp. 1–6.

Heavy-Lift Helicopters; Some Problems Involved in Their Design and Construction. *Bristol Quart.*, Autumn, 1956, pp. 63–66.

Wind Tunnel Development of a Tandem-Rotor Helicopter in Australia. J. R. Marsh. *J. Helicopter Assn. Gt. Brit.*, Dec., 1956, pp. 163–168. Discussion of a program to develop a full-size helicopter using 1/7-scale wind-tunnel model.

Electronic Instrumentation. P. D. McMahon. *Am. Helicopter*, Nov., 1956, pp. 6–8. Development of equipment for



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Strain Gauge and Blade Motion Recoding Systems for Helicopters. P. D. MacMahon. *J. Helicopter Assn. Gt. Brit.*, Dec., 1956, pp. 131–151; Discussion, pp. 151–162. Development of electronic instruments to measure and record stresses and blade motions in helicopter rotors. Discussion includes the Mervyn system of data recording and analysis.

The Effect of Forward-Flight Speed on the Propulsive Characteristics of a Pulse-Jet Engine Mounted on a Helicopter Rotor. Robert D. Powell, Jr. *U.S., NACA TN 3855*, Jan., 1957. 23 pp. Test results which indicate that forward speed decreases mean engine thrust and increases specific fuel consumption.

Design and Flight Test Development of McCulloch VS-57 Supercharger Installation on Hiller Model UH-12B Helicopter. Robert W. Cowgill. *AHS J.*, Jan., 1957, pp. 39–46.

Developments in Cooling Systems for Helicopter Power Plants. H. A. Wahl. *IAS 25th Annual Meeting, New York, Jan. 28–31, 1957, Preprint 701.* 11 pp. Members, $0.35; nonmembers, $0.75. Discussion of means for approaching lower cooling-power absorption by improving airflow cooling characteristics, increasing allowable operating temperatures, and utilizing lower heat-loss components.

Flight Test Development of XV-1 Convertiplane. Marvin D. Marks. (*AHS 3rd Annual Western Forum, Dallas, Oct. 8, 1956.*) *AHS J.*, Jan., 1957, pp. 55–65. Presentation of the highlights of the development and flight-testing program by a figurative breakdown of the aircraft into basic components, and description of the evolution of these individual parts from the time of roll-out in 1954 to their present state.

The Potential of the Helicopter in Mass Transportation. Rita E. Bergman. *AHS J.*, Jan., 1957, pp. 66–68. Results of a helicopter traffic study conducted in Cincinnati, and outline of safety standards.

Safety

Air Safety Problems. Welman A. Shrader and R. C. McGuire. *Aero. Eng. Rev.*, Mar., 1957, pp. 42–46, 56. Summary of the eighth annual international seminar of the Flight Safety Foundation held at Palm Beach, December 3–7, 1956.

U.S. Navy Aviation Safety Program. *U.S., NASC Rep. RA 1-57*, Nov. 20, 1956. 30 pp. Review of the Navy's Aviation Safety program, outlining its objectives, responsibilities, and the existing organization and methods for accomplishing these objectives. Includes a progress report for the 1956 fiscal year.

The Bio-Mechanical Analyses of Survivable-Type Aircraft Accidents as a Factor in Improving Safety. A. Howard Hasbrook. *IAS 25th Annual Meeting, New York, Jan. 28–31, 1957, Preprint 711.* 7 pp. Members, $0.35; nonmembers, $0.75.

The Flight Surgeon and Aircraft Accidents. Carl E. Wilbur. (*IAS 25th Annual Meeting, New York, Jan. 28–31, 1957, Preprint 674.*) *Aero. Eng. Rev.*, Mar., 1957, pp. 57–59. Discussion of the duties required of a flight surgeon to help prevent aircraft accidents. These include analysis of pilot-error accidents and the constant supervision of the pilot's flight readiness.

Ditching Investigations of Dynamic Models and Effects of Design Parameters on Ditching Characteristics. Lloyd J. Fisher and Edward L. Hoffman. *U.S., NACA TN 3946*, Feb., 1957. 58 pp. Experimental results presented in tabular form. Data from other scale-model tests and reports on full-scale ditchings are discussed, and various ditching aids are considered.

General Design Requirements for Crashworthiness and Delethalization of Passenger Transport Aircraft. A. Howard Hasbrook. *IAS 25th Annual Meeting, New York, Jan. 28–31, 1957, Preprint 697.* 6 pp. 23 refs. Members, $0.35; nonmembers, $0.75. Presentation of data on the major factors contributing to injuries in survivable-type accidents involving transport aircraft and of the design precepts which can be used to eliminate these injury causatives.

Technical Bases for Safer Aircraft. Alan L. Morse. *IAS 25th Annual Meeting, New York, Jan. 28–31, 1957, Preprint 675.* 15 pp. Members, $0.50; nonmembers, $0.85. Description of the work of the Aircraft Division of CAA's Indianapolis TDA Center and proposal of a program for the continuation of its activities.

Fire Detection in Aircraft Engine Spaces. *Tech. News Bul.*, Jan., 1957, pp. 8–10. Résumé of studies to provide radiation and flicker measurements for flames as an aid in the development of improved radiant-energy detector designs.

Space Travel

Space Law Bibliography. John C. Hogan. *J. Air Law & Commerce*, Summer, 1956, pp. 317–325.

Legal Problems of Upper Space. John Cobb Cooper. *J. Air Law & Commerce*, Summer, 1956, pp. 308–316. Review of past international treaties and national laws that may be applied to the question of upper-space travel, and suggestions for a new international convention to regulate such travel.

Über die Überbrückung interstellarer Entfernungen. W. Peschka. *Astronautica Acta*, Fasc. 4, 1956, pp. 191–200. In German. Study which shows that distances up to 25 light-years, plus return voyage, may eventually be attainable by means of photon rockets.

Het Geofysisch Jaar en de Satelliet; Wereldomvattende Wetenschappelijke Inspanning. *Avia Vliegwereld*, Dec. 20, 1956, pp. 656–659. In Dutch. Discussion of Project Vanguard, with description and details of the satellite design.

The Vanguard Satellite. Clifford C. Furnas. *Ordnance*, Jan.-Feb., 1957, pp. 596–599. Discussion which includes the launching procedure and describes tracking, recording, and guidance methods.

Vanguard Satellite Tracking Camera Developed. Henry P. Steier. *Missiles & Rockets*, Jan., 1957, pp. 64, 65.

The Uses of Artificial Satellite Vehicles. I. H. E. Canney, Jr., and F. I. Ordway, III. *Astronautica Acta*, Fasc. 4, 1956, pp. 147–174. 67 refs. Applications of space stations to the field of scientific inquiry, presenting the astronomical and astrophysical advantages of such a program.

Structures

The Plastic Theory of Structures. (*Cambridge U., Eng. Dept., Symposium, Sept. 18–21, 1956.*) *Brit. Welding J.*, Jan., 1957, pp. 1–38. 12 refs. Partial contents: Plastic Design of Single-Storey Frames, Jacques Heyman. Multi-Storey Frames, M. R. Horne. Plastic Design and Thermal Stresses, W. Prager. Dynamic Loading and Impact, P. S. Symonds. Some Simple Experiments on the Dynamic Plastic Behaviour of Mild Steel Beams, W. E. Parkes. Frame Instability in the Plastic Range, W. Merchant. Design Problems, M. R. Horne and Jacques Heyman. The Teaching of the Plastic Theory of Structures, J. F. Baker.

Significance of Material Properties in Design for Fatigue Loading. I—Simple Static Stresses; Combined Static Stresses. II—Generalized Failure Theories; Design for Static Stresses; Design for Static Stress Concentration. Joseph Marin. *Mach. Des.*, Jan. 24, Feb. 7, 1957, pp. 88–94; 95–99. 23 refs.

Cylinders & Shells

Matrix Analysis of the Circular Conical Fuselage. I. W. J. Goodey. *Aircraft Eng.*, Jan., 1957, pp. 2–10. Extension of earlier work on a conical fuselage to take into account cutouts in the fuselage frame by treating each stringer as a discrete member instead of continuously distributed reinforcing.

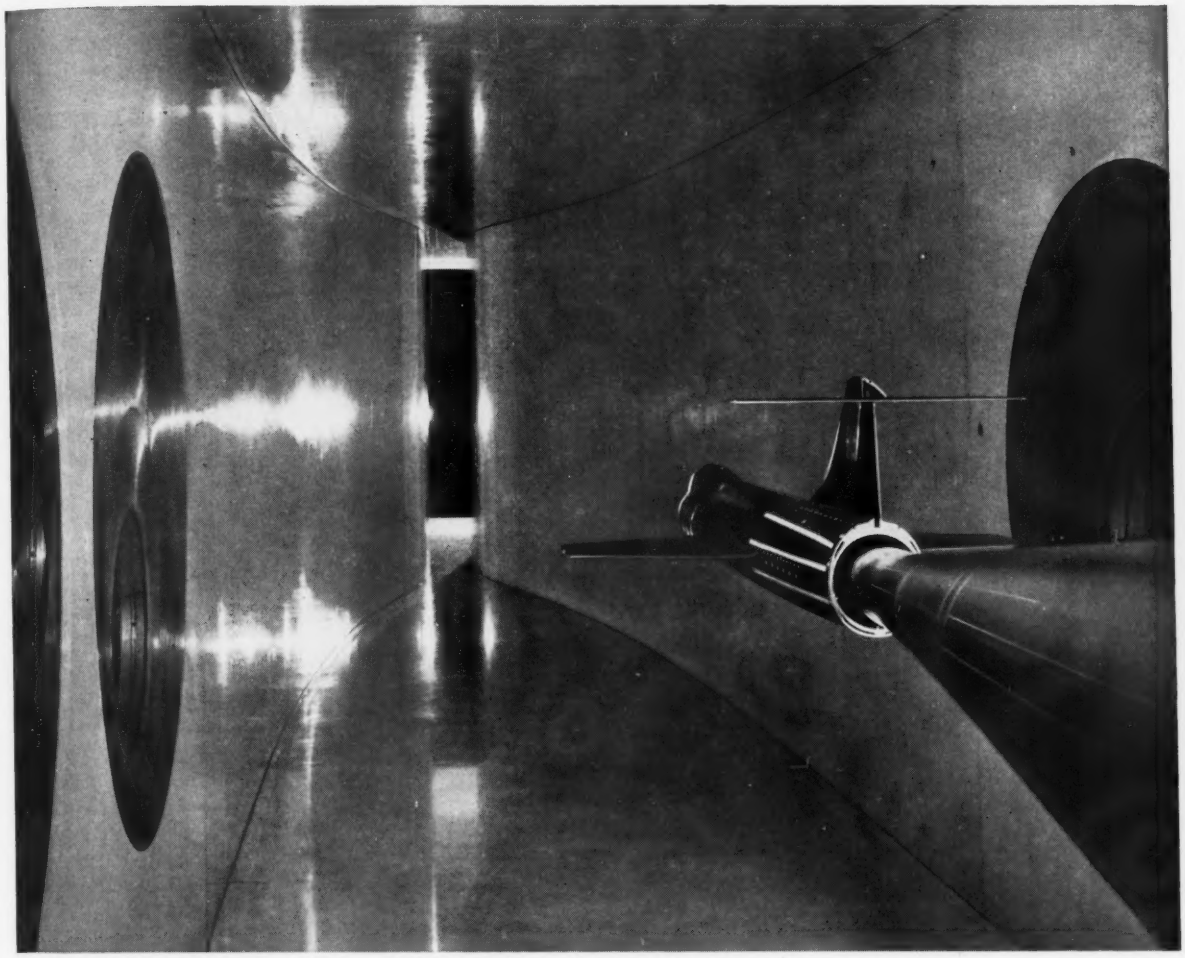
Elasticity & Plasticity

Comportement Général des Matériaux Visqueux dans les Domaines Élastique et Plastique. Henri Le Boiteux and Suzanne Pauthier. *La Recherche Aéronautique*, Nov.-Dec., 1956, pp. 23–30. In French. Study of the general behavior of viscous materials in elastic and plastic domains.

Diffraction of Elastic Waves by a Spherical Surface. Masahumi Nagase. *J. Phys. Soc. Japan*, Mar., 1956, pp. 279–301. 10 refs. Theoretical investigation of the properties of waves in an infinite elastic medium enclosing a spherical cavity. The purpose of the analysis is to clarify the effect of the curvature of a surface on the propagation of elastic waves generated at a point source.

Mechanical Properties of Materials for Combined Stresses Based upon True Stress and Strain. Joseph Marin. *J. Franklin Inst.*, Jan., 1957, pp. 35–46. 16 refs. Application of the simple deformation theory of plasticity to express the plastic combined stress-strain relations in order to formulate, for simple tension, the true roughness in terms of the strain-hardening exponent and the strength coefficient and to determine the yield strength, ultimate strength, ductility, and roughness for combined states of stress.

O Nekotorikh Rabotakh V. M. Panferova po Teorii Uprugo-Plasticheskikh Deformatsii. V. M. Babich. *Prikl. Mat. i Mekh.*, 1956, pp. 767–772. In Russian.



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Discussion of methods developed by Panferov for the theory of elastic-plastic deformations.

Sandwich Structures

Honeycomb Core Materials. A. J. Carah. *Ordnance*, Jan.-Feb., 1957, pp. 727–729. Discussion of properties of honeycomb materials, and applications to design work.

Testing

On the Applicability of Notch Tensile Test Data to Strength Criteria in Engineering Design. J. D. Lubahn. (*ASME Diamond Jubilee Annual Meeting, Chicago, Nov. 13–18, 1955, Paper.*) *Trans. ASME*, Jan., 1957, pp. 111–115; Discussion, p. 115. 19 refs.

Thermal Stress

Heat Problems in High-Speed Flight. *CEC Recordings*, Jan.-Feb., 1957, pp. 12–14. Discussion of heat-testing facilities and some of the equipment used to solve heat problems.

Thermodynamics

Combustion

The Oxidation, Decomposition, Ignition, and Detonation of Fuel Vapors and Gases. XXX—The Hydrogen Engine and Detonation of the End Gas by the Igniting Effect of Carbon Nuclei Formed by Pyrolysis of Lubricating Oil Vapor. R. O. King and S. V. Hayes. *Can. J. Tech.*, Jan., 1957, pp. 442–454.

Spark Ignition of Flowing Gases. Itsuro Kimura and Seiichiro Kumagai. *J. Phys. Soc. Japan*, May, 1956, pp. 599–604. Experimental investigation performed over a wide range of gas velocities including laminar and turbulent conditions, at room temperature, and at atmospheric pressure.

Effect of Particle Size on Combustion of Uniform Suspensions. J. A. Browning, T. L. Tyler, and W. G. Krall. *Ind. & Eng. Chem.*, Jan., 1957, pp. 142–147. 20 refs. OAR-ONR-sponsored investigation to determine a method for better particle-size control in order to extend the lean limits of stable spray combustion.

Use of Temperature-Density for Measuring Antiknock Quality. Bruno R. Siegel. *SAE Annual Meeting, Detroit, Jan. 14–18, 1957, Preprint 54.* 56 pp. Test results which show that the fundamental limitations of existing test methods can be eliminated by operating the laboratory engine at constant fuel-air ratio, peak power spark, and by using manifold air pressure to stress fuels into the knocking zone.

The Structure of Chlorine Flames. Robert F. Simmons and Hans G. Wolfhard. (*ARS Fall Meeting, Buffalo, Sept. 24–26, 1956, Paper.*) *Jet Propulsion*, Jan., 1957, pp. 44–48. 13 refs. Experimental investigation of flames burning on chlorine as the sole oxidant, in order to study the structure, temperature, and spectral emission of hydrogen- and hydrocarbon-chlorine flames.

Stabilization of Premixed Propane-Air Flames in Recessed Ducts. L. W. Huellmantel, R. W. Ziemer, and Ali Bulent Cambel. *Jet Propulsion*, Jan., 1957, pp. 31–34, 43.

Applications of the Electronic Probe to the Study of Turbulent Flames. D. W. Denniston, Jr., J. R. Oxendine, D. H. Knapschaefer, D. S. Burgess, and B. Karlovitz. *J. Appl. Phys.*, Jan., 1957, pp. 70–75. 10 refs. OSR-supported description of a negatively biased bare wire probe with suitable amplification and pulse-height discrimination to be used in detecting flame fronts in turbulent motion.

Photographic Studies of Turbulent Flame Structure. Joseph Grumer, Joseph M. Singer, J. Kenneth Richmond, and James R. Oxendine. *Ind. & Eng. Chem.*, Feb., 1957, pp. 305–312. 13 refs. Investigation of photographic techniques which concludes that schlieren, shadow, and smoke photography are inadequate tools for analyzing the structure of a turbulent flame brush.

Heat Transfer

The Use of Sodium and of Sodium-Potassium Alloy As a Heat-Transfer Medium. W. B. Hall and T. I. M. Crofts. *IME Proc.*, No. 10, 1956, pp. 321–330; Discussion, pp. 331–337; Communications, p. 337; Author's reply, pp. 338, 339. 13 refs. The application of liquid metals to heat-transfer problems is discussed, and comparisons are made between such metals. A general discussion is given on the design and construction of liquid metal circuits and their components.

Heat Loss from a Partially Insulated Solid Body. Joseph Gillis. *J. Phys. Soc. Japan*, Sept., 1956, pp. 993–1,003. Investigation of a thermally conducting solid in which the uninsulated part of the surface radiates heat into a medium at zero temperature.

O Reshenii Odnoi Zadachi Teploprovodnosti. T. Kh. Sedel'nikov. *Prikl. Mat. i Mekh.*, 1956, pp. 766, 767. In Russian. Development of a method to solve the problem of heat transfer.

Wärmeübergang und Druckabfall in rauhen Rohren. H. E. Brachetti. *VDI Zeitschrift*, Dec. 21, 1956, pp. 1,953, 1,954. In German. Study of heat transfer and pressure loss in roughness models.

VTOL & STOL

First Moves to Vertical Take-Off. *The Aeroplane*, Dec. 28, 1956, pp. 950–952. Discussion of the Short S.C.1 VTOL research aircraft in terms of its Rolls-Royce RB.108 power plant and its vertical flight control.

"Kurzstart"—Ein neuer Abschnitt der Luftfahrtentwicklung. K. W. Mack. *Luftfahrttechnik*, Jan. 15, 1957, pp. 2–11. 38 refs. In German. Discussion of VTOL and STOL aspects in terms of airport and safety requirements.

The Approaching Era Of VTO. Stanley Hiller, Jr. *Am. Helicopter*, Nov., 1956, pp. 9–12. Description of a proposed design for a tilt-wing, turboprop-powered, VTO aircraft, and discussion of its operation and performance.

Powerplants for VTOL Aircraft. Peter G. Kappus. *IAS 25th Annual Meeting, New York, Jan. 28–31, 1957, Preprint 667.* 7 pp. Members, $0.35; nonmembers, $0.75. Discussion of power-plant require-

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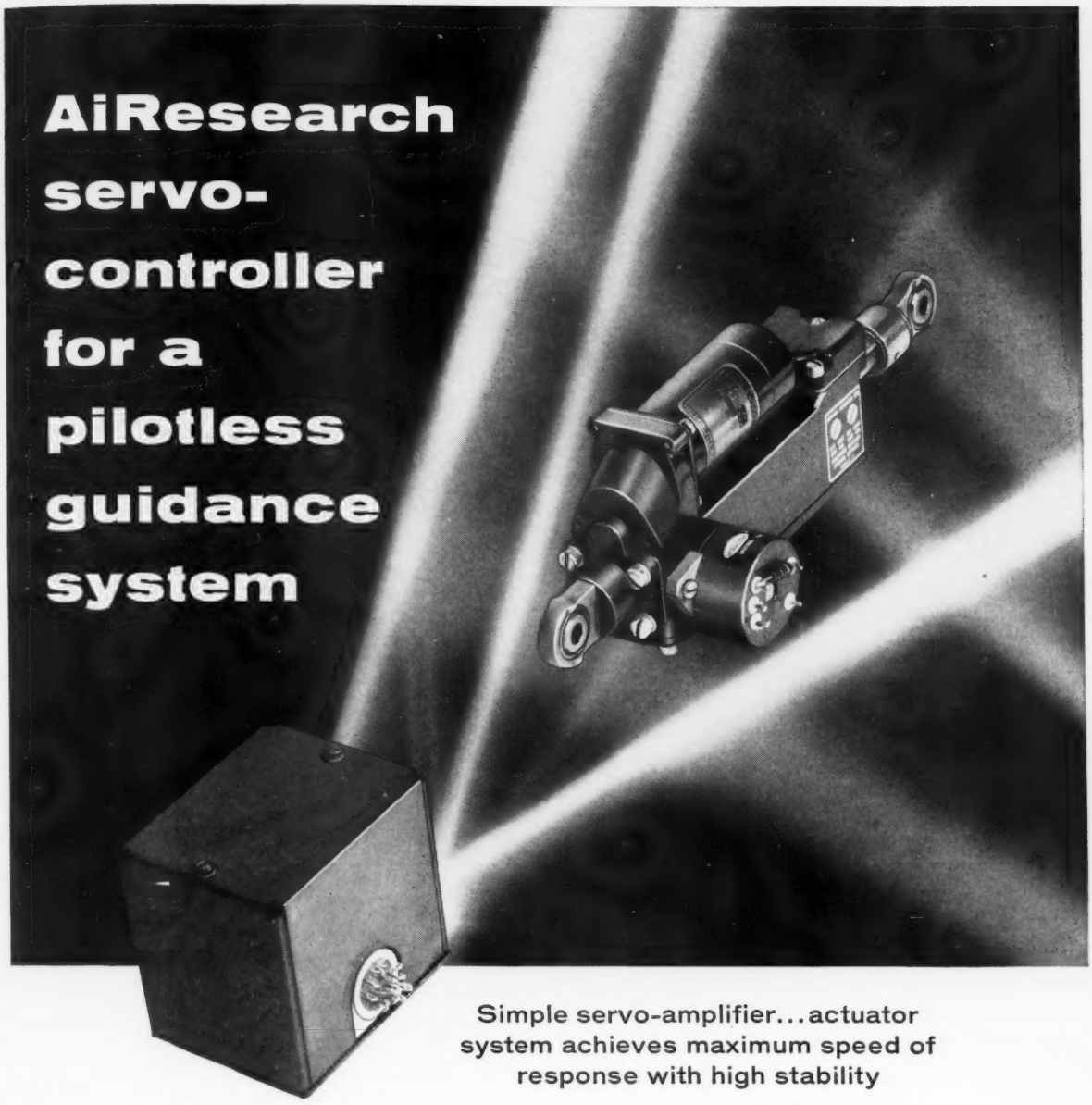

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ments in terms of engine specific weight and specific fuel consumption.

The Jet Wing. John S. Attinello. *IAS 25th Annual Meeting, New York, Jan. 28–31, 1957, Preprint 703.* 15 pp. 23 refs. Members, $0.50; nonmembers, $0.85. Discussion of the basic concepts, development, and some of the problems to be overcome in perfecting the jet wing.

Water-Borne Aircraft

Design Trends in Water-Based Aircraft. John D. Pierson. *Aeronautics*, Jan., 1957, pp. 22–25. Discussion of the aerodynamic-hydrodynamic progress in the development of high-speed flying boats.

Wind Tunnels & Research Facilities

A Note on Multiple Diaphragm Shock Tubes. G. A. Bird. *Gt. Brit., RAE TN Aero.2469*, Oct., 1956. 10 pp. Discussion drawing attention to the effects of the secondary waves produced by wave interactions in shock tubes having more than one diaphragm.

An Index of Mathematical Tables for Shock-Tube Flow. B. D. Henshall. *Gt. Brit., ARC CP 292*, Jan. 24, 1956. 7 pp. 18 refs. BIS, New York, $0.27.

A New Wind Tunnel. *Bristol Quart.*, Autumn, 1956, pp. 73–76. Description of the 12-ft. wide and 10-ft. high wind tunnel, large enough to accommodate a model of 9-ft. span and designed for speeds no greater than 300 ft./sec.

Ames Light-Gas Gun. A. C. Charters. *Shell Av. News*, Dec., 1956, pp. 12–14. Description of a gun used to fire models at speeds up to Mach 20, using compressed helium as a propellant force.

The Shock Tube. F. S. Sherman. *U.S., ONR Res. Rev.*, Jan., 1957, pp. 1–9. Description of the various appearances and modes of operation of the instrument, with details of the four types—piston, diaphragm, solid-explosive, and electric—and discussion of research applications.

A Divergent Shock Tube for Obtaining Supersonic Flows. Fumio Tamaki. *J. Phys. Soc. Japan*, Apr., 1956, pp. 434–439. Description of a device consisting of a shock tube with a divergent low pressure just downstream of a partition diaphragm. Flow character in the divergent channel is examined theoretically and experimentally, and interferometric studies of the flow past a double-wedge profile are presented for Mach Numbers of 4.0 and 6.0.

A High Temperature-Pressure Air Heater (Suitable for Intermittent Hypersonic Wind-Tunnel Operation). Martin H. Bloom. *USAF WADC TN 55-694 [AD 110725]*, Nov., 1956. 30 pp. 40 refs. Discussion of the design, construction, and operation of a convection heater suitable for supplying pure air intermittently.

Development and Application of a High-Temperature, High-Pressure Storage Heater. B. V. Rhodes. *USAF AEDC TN 56-18 [AD 110829]*, Jan., 1957. 30 pp. Description of a graphite-filled, storage-type heater for heating nitrogen gas up to stagnation temperatures of 3,500°R. at stagnation pressures of 10,000 psi.

Hot Water Injection Cuts Wind Tunnel Costs. Otto Frenzl. (*SNECMA 2nd European Aero. Cong., Scheveningen, Sept., 1956, Paper.*) *Av. Age*, Feb., 1957, pp. 58–63 ff. Abridged. Discussion of a steam injector used in supersonic tunnels, with details of its operational advantages and description of the process.

Prove di Visualizzazione del Flusso Nello Strato Limite Alla Galleria del Vento a Bassa Velocità. Ermanno Bazzocchi. *L'Aerotecnica* (Rome), Oct., 1956, pp. 315–332. In Italian. Boundary-layer flow-visualization tests in a low-velocity wind tunnel performed on a swept and an unswept wing with a mixture of kerosene and carbon black. The relations between the aspects and modifications of flow in the boundary layer and the behavior of forces and moments on the two wings are shown.

Flutter Model Testing at Transonic Speeds. Walter P. Targoff and Richard P. White, Jr. *IAS 25th Annual Meeting, New York, Jan. 28–31, 1957, Preprint 706.* 15 pp. Members, $0.50; nonmembers, $0.85. Description of model-construction techniques and tests for flutter testing in a transonic wind tunnel.

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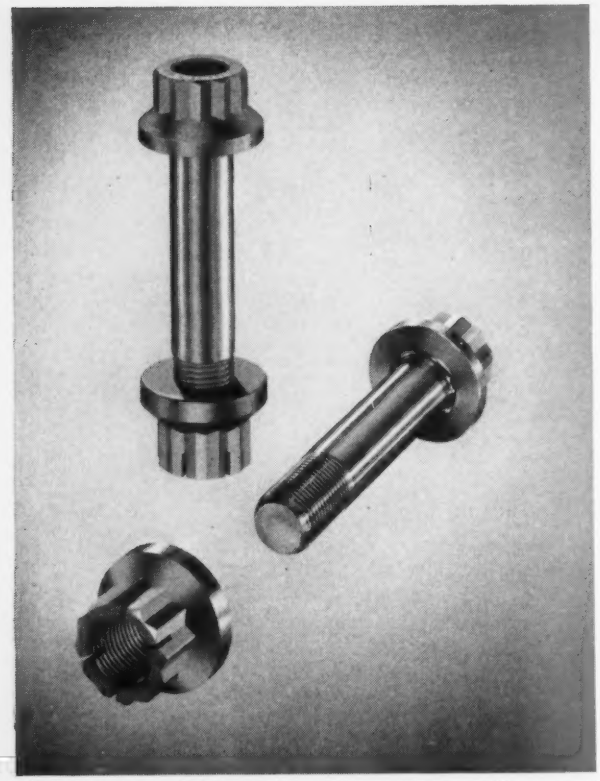

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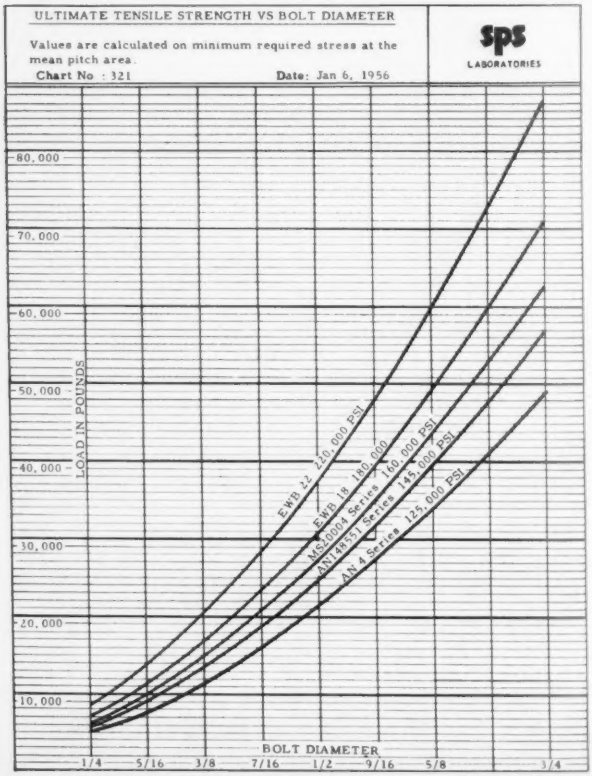

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Aeronautical Reviews — BOOKS

ACOUSTICS

Technical Aspects of Sound; Vol. 2, Ultrasonic Range, Underwater Acoustics. Edited by E. G. Richardson. Amsterdam, Elsevier Publishing Company; Princeton, N.J., D. Van Nostrand Company, Inc., 1957. 412 pp., illus., diagrs., tables. $11.75.

This modern survey of acoustic science presents the basic theory of acoustics together with the applications of sound and ultrasonics. The book is a collective effort by scientists of international repute and is edited by E. G. Richardson, Professor of Acoustics, King's College, University of Durham. The eleven chapters are divided into three sections: Ultrasonic Transducers and Applications, Underwater Acoustics, and Aircraft Noise.

The section on Aircraft Noise was contributed by Harvey H. Hubbard, Leslie W. Lassiter, and Arthur A. Regier, all of the Langley Aeronautical Laboratory, NACA. It has chapters on propeller noise, jet noise, other sources of aircraft noise and comparative noise levels, and sounds of propulsion in water (the latter by Professor Richardson). *Volume I* of the set appeared in 1953.

AERODYNAMICS

Elements of Gas Dynamics. H. W. Liepmann and A. Roshko. New York, John Wiley & Sons, Inc., 1957. 439 pp., diagrs., tables. $11.

This is the latest volume to appear in the GALCIT Aeronautical Series, which is prepared under the editorship of Theodore von Kármán and Clark B. Millikan. The aim of the authors, who are Professor and Assistant Professor of Aeronautics, respectively, at the California Institute of Technology, is to provide a working understanding of the essentials of gas flow with particular reference to their application in high-speed aerodynamics. To this end they have concentrated on fundamentals; specific design data and configurations are purposely omitted in favor of general principles and essentials that clearly illustrate the theory. The book is intended mainly for students in aeronautics, but it can reasonably be expected to be useful to practicing engineers and scientists who work on problems involving the aerodynamics of compressible fluids.

Contents: (1) Concepts from Thermodynamics. (2) One-Dimensional Gasdynamics. (3) One-Dimensional Wave Motion. (4) Waves in Supersonic Flow. (5) Flow in Ducts and Wind Tunnels. (6) Methods of Measurement. (7) The Equations of Frictionless Flow. (8) Small Perturbation Theory. (9) Bodies of Revolution Slender Body Theory. (10) The Similarity Rules of High-Speed Flow. (11) Transonic Flow. (12) The Method of Characteristics. (13) Effects of Viscosity and Conductivity. (14) Concepts from Gaskinetics. Exercises. Selected References. Tables. Charts.

Momentum Transfer in Fluids. Wm. H. Corcoran, J. B. Opfell, and B. H. Sage. New York, Academic Press, Inc., 1956. 394 pp., diagrs., tables. $9.00.

Laminar and turbulent shear-flow, boundary-layer analysis, and a statistical treatment of turbulence are the areas of fluid mechanics specifically treated in this volume written for chemical engineers. The text should provide a sufficient background in these subjects to give the reader a reasonable understanding of the nature of local fluid motions that are of primary importance in thermal and material transport. The described conditions of flow are limited to those frequently encountered in industrial practice. Consideration is given to situations where variations in the molecular properties of the fluid with position are encountered. A knowledge of calculus and the elementary principles of differential equations are prerequisites to an understanding of the text. Nomenclature and copious literature reference conclude all but two of the chapters and appendixes. The authors are associated with the Chemical Engineering Laboratory, California Institute of Technology.

AERONAUTICS, GENERAL

Jahrbuch 1955 der Wissenschaftlichen Gesellschaft für Luftfahrt (WGL); Mit den Vorträgen der WGL-Tagung in Augsburg vom 12. bis 15. Oktober 1955. (WGL Yearbook 1955; with the Papers Presented at the WGL-Meeting in Augsburg, October 12–15, 1955.) Edited by Hermann Blenk. Braunschweig, Friedr. Vieweg & Sohn, 1956. 360 pp., illus., figs., tables. DM 48.

Contents (Titles are given in English; papers are in German unless indicated otherwise): The Aircraft Industry and Science, W. Messerschmitt. 55 Years of Powered Flight; Forces, Men, and Systems, A. Baeumker. New Results and Development Possibilities in Theoretical Gas Dynamics, R. Sauer. Journey by Air from the Legal Point of View, A. Meyer. Safety in Civil Aviation; Conclusions and Lessons from Foreign Aircraft Accident Analyses, E. W. Pleines. Meteorological Problems of Air Transport over the Equitorial Atlantic Enroute to Argentina-Chile, W. Georgii. The Significance of Automatic Controls for Blind Landing, G. Klein. Problems of Automatic Control of Aircraft, K. H. Doetsch. Trends in Autopilot Developments, W. P. Lear (in English). Remote Control and Blind Landing in Civil Aviation, USA, J. L. Anast (in English). The Status of Development in Aerial Photogrammetry, W. A. Brucklacher. Visual Aids and their Effect on Landing Success and Safety, E. S. Calvert (in English). Visibility and Visibility Recording, L. Foitzik. Instruments for Flight and Engine Control, C. N. Jaques (in English). An Instrument for the Determination of a Point and of Geographical North by Simple Aiming: The ONERA Spherant, R. Claret (in French). The Application of Airborne Radar in Commercial Aviation, K. E. Karwath. The Aerodynamics of Wings from the Aircraft Designer's Point of View, E. Truckenbrodt. Investigations on the Downwash Behind Delta Wings in Incompressible Flow, K. Gersten. The Neutral Point of Aircraft, H. Wurster. Interference Between the Fuselage and a Wing of Small Aspect Ratio According to Slender Body Theory, W. Jacobs. The Aerodynamics of Annular Airfoils, G. Richter. On an Approximation Theory for the Calculation of Nonlifting Flow Around Slender Bodies at Sonic Velocity, F. Keune. Transonic Flow around Airfoils with the Mach Number of Undisturbed Flow Equal to Unity, S. Nocilla. Theoretical Evaluation of Spoiler Effectiveness in the Supersonic Region, W. Seibold. Calculation of the Characteristic Curve of an Axial Compressor on the Basis of Theoretical Boundary Layer Investigations of Cascades, N. Scholz. Development of an Approximation Method for the Calculation of Three-Dimensional Cascade Flows, H. J. Schröder. On the Development of Intermittent Wind Tunnels with Jet Drives, O. Frenzl. Research Methods and Studies for Modern Aircraft, F. Vinsonneau (in French). Contributions to Propeller Theory, O. Tietjens. Performance Determination and Operational Problems, L. Lazzarino (in English). Diagrammatic Representation of the Processes in Combustion Chambers and Ram Jet Power Plants, O. Lutz. On the Sonic and Ultrasonic Waves Emitted by Jet Engines, F. Staab. Damages Attributed to Aircraft Noise, J. T. Lacour. Cargo Airplanes, L. Coroller. The Jet-Wing Aircraft; A Solution to the Problem of Short and Vertical Take-Off, B. de Pontfarcy. Construction and Possibilities of the SE. 5000 Baroudeur Airplane, J. Dor (in French). The SE. 3130 Alouette II Helicopter and its Future Development, C. Marchetti (in French). Prestressed Shell Construction, H. Hertel. High-Strength Aluminum Alloys and Their Application in Aircraft Design, P. Brenner. Application and Mechanical Treatment of Extruded Shapes in Aircraft Construction, H. Hornauer. The Status of High-Temperature Sinter Material Research, E. Meyer-Hartwig.

Included are brief reports submitted by the following firms: Simmonds Aerocessories, Ltd. (Gt. Brit.); SNECMA; SNCASO; Vereinigte Leitchmetall-Werke, G.m.b.H.; and Vereinigte Deutsche Metallwerke A.G. The volume concludes with a section giving the yearly administrative reports of the WGL.

COMPUTERS

Automatic Digital Calculators. Andrew D. Booth and Kathleen H. V. Booth. 2nd Ed. London, Butterworths Scientific Publications; New York, Academic Press, Inc., 1956. 261 pp., illus., diagrs., tables. $6.00.

A guide to the theory, design, construction, and use of digital calculators. The text of this revised edition has been augmented with material on new circuit elements, such as the transistor and the ferro-electric matrix store, and a description of automatic coding procedures devised since publication of the first edition (London,

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1953). The bibliography has been expanded from 231 to 714 references, arranged by subject.

DICTIONARIES

English-Russian, Russian-English Electronics Dictionary. U.S. Dept. of the Army. (Technical Manual TM 30-545.) Washington, Superintendent of Documents, August, 1956. 944 pp. $3.50.

This dictionary is an overall collection of about 22,000 Russian terms and abbreviations covering many fields in the areas of electronics and telecommunication. Among those fields covered are aeronautical applications, computers, electroacoustics, measurements, navigation, radar, semiconductors, telemetering, and tubes. Some terms from allied sciences have also been included. The most recent sources available have been used in the present compilation. In addition to the sources published in the United States, the U.S.S.R., and the United Kingdom, many Russian terms have been obtained from Soviet factories, research institutions, and individual scientists. Useful features are the extensive cross references, the explanatory glosses indicating the branch of science or engineering to which terms refer, and special aids showing the meaning of a basic term in specialized uses.

HELICOPTERS

Introduction to Helicopter Aerodynamics. W. Z. Stepniewski. Rev. Ed. Incorporating "Typical Helicopter Performance Calculation," by J. J. Harris, L. H. Sloan, and K. W. Ulrich. (Rotary Aircraft Series, No. 3.) Morton, Pa., Rotorcraft Publishing Committee, 1956. 257 pp., diagrs., tables. $4.50.

The inclusion of performance calculations makes this work, first published in 1950, a comprehensive engineering reference on fundamental helicopter theory. The book is divided into three major sections: Fundamentals of Rotary Wing Aerodynamics, Practical Methods of Helicopter Performance Prediction, and Typical Helicopter Performance Calculation. Included are the latest studies made by the NACA and other research agencies. The subject matter is broad, but mathematical complexity is avoided wherever possible. It is thus hoped that the material will be found suitable for the graduate student and that the reader with the theoretical background of an average mechanical engineer will be able to grasp the fundamentals of helicopter aerodynamics. Diagrams are profuse, and each chapter contains a separate bibliography. A list explaining the symbols used precedes the text. Mr. Stepniewski is Chief of Research & Development, Vertol Aircraft Corporation. R. J. Harris and L. H. Sloan are aerodynamics engineers at the same firm, and K. W. Ulrich is an aerodynamicist at Grumman Aircraft Engineering Corporation.

INFORMATION THEORY

Science and Information Theory. Leon Brillouin. New York, Academic Press, Inc., 1956. 320 pp., diagrs., tables. $6.80.

Based on lectures delivered before engineers of the International Business Machines Corporation and at the University of California, Professor Brillouin's book discusses the practical relationship between physical science and the new theory of information and illustrates the manner in which the methods of this theory can be successfully applied to all technical problems concerning information: coding, telecommunication, mechanical computers, etc. The employment of the entropy of physical systems as a measure of lack of information is presented as justified by a variety of examples ranging from theoretical physics to everyday life. This point of view is defined as the negentropy principle of information and leads to a new investigation of the efficiency of different methods of observation, as well as their accuracy and reliability.

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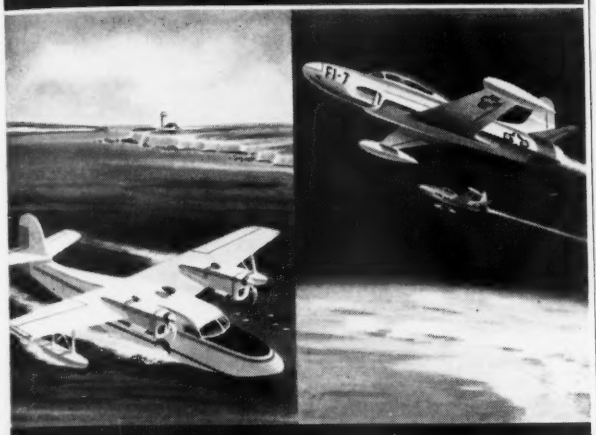

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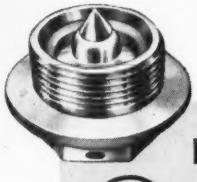

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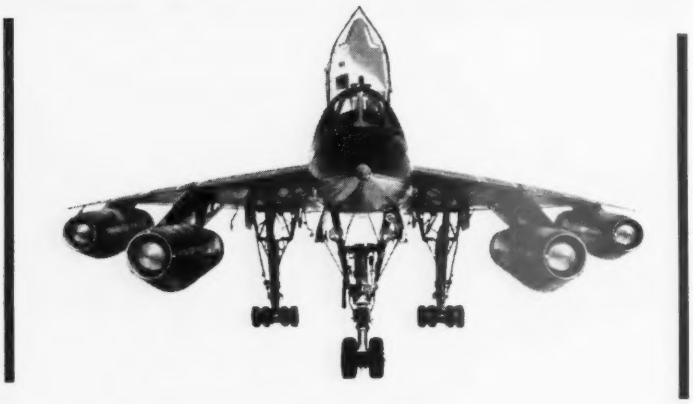

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Information Theory. Papers Read at a Symposium on "Information Theory" Held at the Royal Institution, London, September 12–16, 1955. Edited by Colin Cherry. London, Butterworths Scientific Publications; New York, Academic Press, Inc., 1956. 401 pp., diagrs., tables, illus. $11.50.

Thirty-five papers were read and discussed at the Third London Symposium on Information Theory and are grouped into five sections of closely related areas of study and application. These proceedings, which include contributions of scientists and researchers from 15 different countries, contain material of direct relevance to many varied disciplines, such as optics, telecommunications, taxonomy, linguistics, information storage and retrieval, mechanical translation, semantics, physiology, and psychology.

Contents: (1) Fundamentals. (2) Coding, Taxonomy, etc. (3) Language Analysis and Mechanical Translation. (4) Meaning and the Human Senses. (5) Behavior and its Mechanism.

MATERIALS

Rheology, Theory and Applications, Vol. 1. Edited by Frederick R. Eirich. New York, Academic Press, Inc., 1956. 761 pp., diagrs., tables. $20.

In this volume, the first of three devoted to summarizing experimental and theoretical knowledge in the science of deformation and flow, noted workers in rheology have contributed introductory and descriptive material designed to bring about a better understanding of the essential unity of this growing field. It presents a condensation of facts and theories on a variety of topics, ranging from metallurgy, glasses, and acoustics to rubbers, fibers, gels, ceramics, inks, solutions, and pastes. The Editor is associated with the Department of Chemistry, Polytechnic Institute of Brooklyn.

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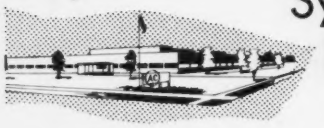

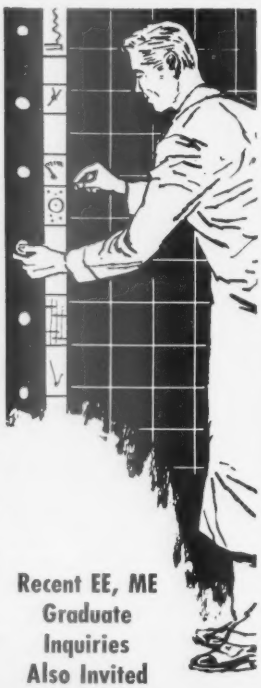

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(16) Non-Newtonian Flow of Liquids and Solids, J. G. Oldroyd. (17) Acoustics and the Liquid State, R. B. Lindsay.

Analysis of Deformation; Vol. 3, Fluidity. Keith Swainger. London, Chapman & Hall, Ltd.; New York, The Macmillan Company, 1956. 266 pp., diagrs. $13.50.

"All substances deform under applied loads. This phenomenon is the aspect of natural science considered in the present work after imposing certain idealising restrictions to bring such a wide subject within the scope of one set of mathematically linear equations." This statement from *Volume 1* of the series indicates the general approach of *Volume 3*, which focuses attention on the fluidity aspects of the deformation problem. Since the topic is one in theoretical and applied mechanics or physics, mathematics has been kept to a minimum. Whatever mathematics is required is given briefly in the appendixes, together with sufficient explicit references for collateral reading.

Source material consists of standard histories, textbooks of long standing, and articles from journals published over the past decade. Supporting material consists of a check-list to explain the principal notations used in the text, a glossary to define the less familiar technical terms, a bibliography of 95 references, and author and subject indexes. *Volumes 1* and *2* were published in 1954–1955 by Macmillan. The author was recently Imperial Chemical Industries Research Fellow, University of London.

Contents: (1) Introductory. (2) Mathematical Formulation. (3) Classical Mathematical Formulation. (4) Viscous, Plane Flow. (5) Three-Dimensional, Viscous Flow. (6) Stress-Fluidity. (7) Boundary Conditions and Their Influence on the Flow. Appendix A, Vector Analysis. Appendix B, Rigid Body Motion.

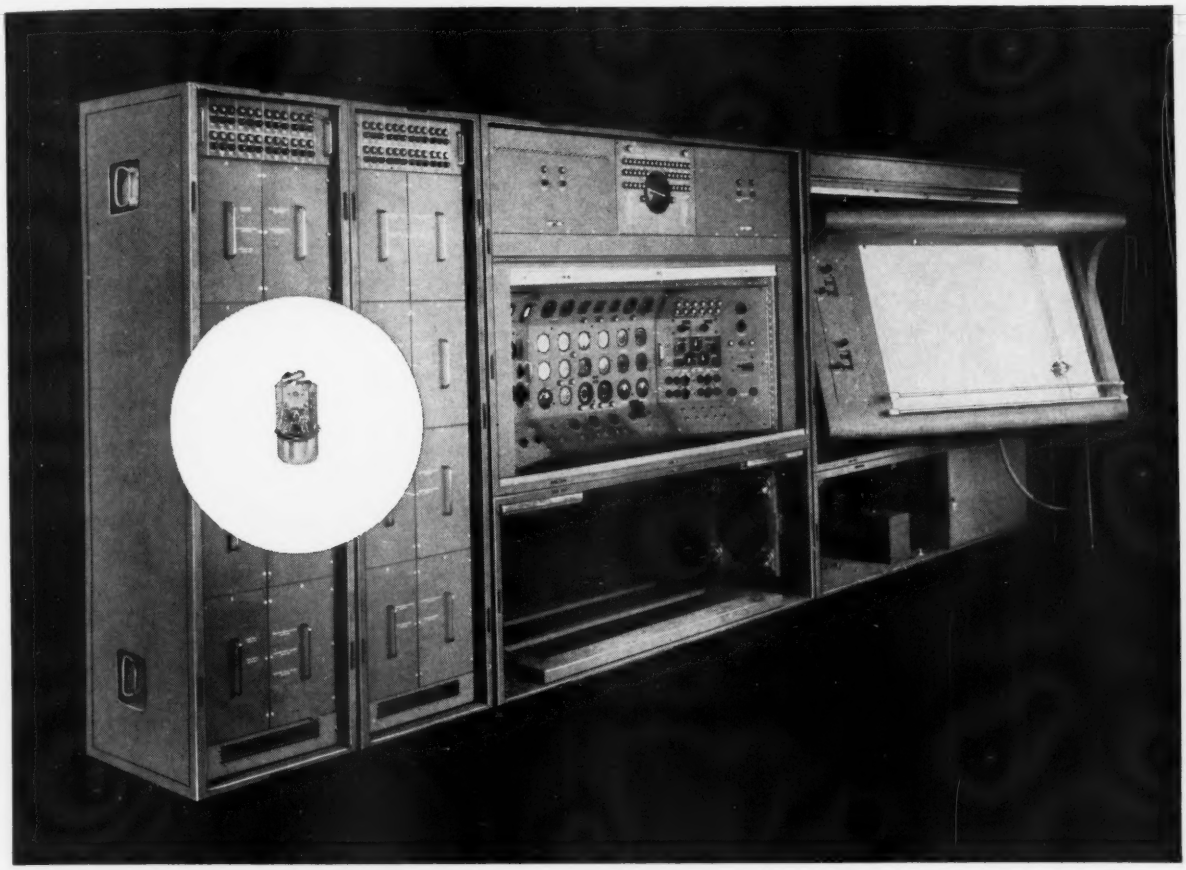
Elasticity, Fracture and Flow; With Engineering and Geological Applications. J. C. Jaeger. London, Methuen & Co., Ltd.; New York, John Wiley & Sons, Inc., 1956. 152 pp., diagrs., tables. $2.50.

An introduction to the basic mathematics of the theories of elasticity, plasticity, viscosity, and rheology, together with a discussion of the properties of the materials involved and the way in which they are idealized to form a basis for the mathematical theory. This monograph is intended for readers such as engineers and geologists whose interest is in the assumptions of the theory involved and the way in which they affect the solutions, rather than in the study of special problems. The author is Professor of Geophysics, Australian National University.

Contents: (1) Stress and Strain. (2) Behavior of Actual Materials. (3) Equations of Motion and Equilibrium. Index.

Defects and Failures of Metals, Their Origin and Elimination. E. P. Polushkin. Amsterdam, Elsevier Publishing Company; Princeton, N.J., D. Van Nostrand Company, Inc., 1956. 399 pp., illus., diagrs. $12.50.

Engineers, metallurgists, and others concerned with producing, fabricating, treating, testing, or inspecting metals and metal products will find this comprehensive volume a practical guide in their everyday work. The failures and defects of whole field metals and their alloys are examined in separate chapters dealing with segregation, blowholes and porosity, pipe, impurities, decarburization of steel, scaling, harmful effects of residual stresses, fatigue, flakes, failures in heat treatment, embrittlement, cracks, defects in shape, surface and size of metals, wear, and corrosion. The origin, causes, and elimination of these failures are described; wherever applicable, the close correlation between types of failures is shown. The bibliography that accompanies each chapter is intended to present a condensed review of all available sources of information on each subject of metal failures. The author is a consulting metallurgical engineer and was formerly Associate Professor of Metallurgy, Stevens Institute of Technology.



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MATHEMATICS

Fundamental Concepts of Algebra. Claude Chevalley. (Pure and Applied Mathematics, Vol. 7.) New York, Academic Press, Inc., 1956. 241 pp. $6.80.

A book which gears the teaching of algebra to the mathematical requirements of the present. The contents of this text, encompassing monoids, groups, rings and modules, algebras, and associative algebras, were taught by the author at Columbia University in a graduate course in algebra.

METEOROLOGY & THE ATMOSPHERE

Flugmeteorologie (Aviation Meteorology). Walter Georgii. 2nd Rev. Ed. Frankfurt, Akademische Verlagsgesellschaft m.b.H., 1956. 332 pp., illus., diagrs., tables. DM 35. In German.

Dr. Georgii, who is now a member of the Council of the German Research Institute for Soaring Flight (DFS) in Munich, has selected and presented his material with a particular audience in mind: experienced pilots of powered aircraft, and glider pilots as well; meteorologists who will be acquainted with the theory underlying the data offered; and scientists, who will find the theory supplemented by so many actual flight examples that this book will be in a certain way an applied aerology.

Because three decades have passed since publication of the first edition (1927), the present volume is substantially a new work. New developments and knowledge gained during the war and postwar years have been included. Beginning in 1948 the author participated in actual flights in various climates and under widely varying weather conditions; for a 4-year period he made numerous research flights in aircraft of the Argentinian Air Force. Information gained from these observations and flight experiences plays an important role in the presentation. Aviation weather forecasting is not treated since it is believed to belong rather in the field of those services concerned with flight safety, so that the text is more or less limited to those phenomena which are met in flight and which the pilot must use his own judgment to combat.

Contents: (1) Meteorology and Aeronautics. (2) Structure of the Atmosphere. (3) Thermodynamics of the Dry Atmosphere. (4) Thermodynamics of the Moist Atmosphere. (5) Condensation and Precipitation. (6) Thunderstorms. (7) Clouds. (8) Artificial Modification of Clouds and Precipitation. (9) Air Masses. (10) Fronts. (11) Ice Formation on Airplanes. (12) The Subtropical and Tropical Air Space. (13) Jet Streams and Wave Soaring. Bibliography (107 references). Author Index. Subject Index.

Physikalisch-Statistische Regeln als Grundlagen für Wetter- und Witterungsvorhersagen, Erster Band (Physical-Statistical Rules as Bases for Forecasts of Weather and Weather Character, Volume 1). Franz Baur. Frankfurt, Akademische Verlagsgesellschaft m.b.H., 1956. 141 pp., illus., diagrs., tables. DM 42. In German, with preface and chapter headings in English.

Dr. Baur, who is Honorary Professor at the University of Frankfurt-am-Main, states that his aim is to show that "guided by physical considerations, rules can be found regarding connections between consecutive weather phenomena or between 'Grosswetter' (general weather patterns) and solar phenomena by statistical investigations based on a large body of observations. Such rules have proved true throughout entire records of 70 to 170 years *without exception* or at least with a relative frequency very close to one. The number of cases is so great that chance (instead of causal connection between the phenomena in question) can practically be excluded." Much of this volume concerns the weather of central Europe and its applicable rules; however, certain material is of world-wide significance, and some is particularly applicable to North America.

Contents: Introduction. (1) Statistical Bases for Forecasts in the Daily Weather Service. (2) Theoretical Considerations into Variations

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STRATEGIC WEAPON—Closely shrouded in secrecy during years of development and testing, the Snark SM-62, like the powerful queen in chess, is an important strategic weapon. The Snark, America's first intercontinental guided missile, is now scheduled for delivery to the Strategic Air Command of the U.S. Air Force. Designed to deliver a nuclear warhead to a target 5,000 miles from its mobile launching platform, the Snark is a strong deterrent to any aggressor. Like the new Northrop T-38 supersonic jet trainer, the Snark was developed with Northrop's realistic understanding of national defense budget limitations. These, and other weapon systems designed and produced by Northrop, are examples of the continued corporate effort to aid the defense department in maintaining "security with solvency" by using the best resources of science and technology to develop low-cost solutions to defense problems.

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The Airglow and the Aurorae; A Symposium Held at Belfast in September, 1955. Editors: E. B. Armstrong and A. Dalgarno. (*Journal of Atmospheric and Terrestrial Physics*, Special Supplement, Vol. 5.) London, New York, Pergamon Press, 1956. 420 pp., illus., diagrs., tables. $22.50.

In view of the imminence of the International Geophysical Year, the 53 papers presented at this conference—held at the Queen's University at Belfast—assume significant importance and constitute a source of study and reference for those concerned with the phenomena of the upper atmosphere. Much of the material presented is original work appearing for the first time. Included are contributions from Great Britain, France, the United States, Germany, Belgium, Canada, Norway, Japan, and the U.S.S.R.; the seven Soviet contributions are presented in English. The proceedings contain descriptions of the most recent observational studies in different parts of the world, of laboratory investigation and quantal calculations, and the details of new ground-based and air-borne observational techniques.

Contents: (1) Introduction. (2) Observations of the Airglow. (3) Observations of Aurorae. (4) Theoretical Considerations on the Airglow. (5) Theoretical Considerations on Aurorae. (6) Laboratory Studies. (7) Quantal Calculations. (8) Instrumentation. Subject Index. Name Index.

Solar Eclipses and the Ionosphere; A Symposium Held Under the Auspices of the International Council of Scientific Unions Mixed Commission on the Ionosphere, London, August, 1955. Edited by W. J. G. Beynon and G. M. Brown. (*Journal of Atmospheric and Terrestrial Physics*, Special Supplement, Vol. 6.) London, New York, Pergamon Press, 1956. 330 pp., diagrs., tables. $21.

The 53 papers presented at this symposium provide a comprehensive survey of the status of research on the influence of solar eclipses on ionospheric phenomena. The volume is international in character including, as it does, the results of experiments carried out by scientists of 18 countries. Summaries of the discussion sessions are given, and an exhaustive bibliography of literature on solar eclipses and the ionosphere, arranged chronologically, has also been supplied.

Contents: (1) Introduction. (2) Theoretical Considerations. (3) Ionospheric Eclipse Results. (4) Solar Radiation and Layer Theory. (5) Recombination. (6) Geomagnetic Eclipse Phenomena. (7) Solar Radio Noise. (8) Miscellaneous. (9) Conclusion.

OPTICS

Proceedings of a Symposium on Astronomical Optics and Related Subjects; Held in the University of Manchester, April 19–22, 1955. Edited by Zdeněk Kopal. Amsterdam, North-Holland Publishing Company; New York, Interscience Publishers, Inc., 1956. 428 pp., diagrs., illus., tables. $12.50.

The aim of this symposium was twofold: to provide a forum for discussion of certain fields in optics which were of timely interest and astronomical significance and to strengthen further the liaison between astronomy and optics by bringing current astronomical desiderata to the attention of contemporary optical experts. The scope of the meeting was international, contributions being received from France, Germany, Great Britain, Holland, Italy, Canada, and the United States, and the volume itself is multilingual in character.

The principal subjects discussed are the bearing of information theory in optics, optical images and diffraction, interferometry and coherence problems, electronic devices currently employed in astronomical observation, resolution problems and scintillation, wide-angle optical systems and aspheric surfaces, and filter photography and thin films. Particular attention is called to both the contributions and shortcomings of photographic methods of astronomical observation, and the inference is made that they are likely to be displaced by photoelectric and television methods in the not too distant future.

PROPELLERS

Aircraft Propeller Handbook. Issued by the USAF ARDC, Navy Bureau of Aeronautics, and Civil Aeronautics Administration. (ANC-9 Bulletin.) Washington, Superintendent of Documents, September, 1956. 391 pp., illus., diagrs., tables. $2.25.

This handbook has been prepared for use as a general guide in connection with some of the most common problems associated with design, construction, and use of both military and commercial aircraft propellers. Specifically, it has been prepared for the following processes:

(a) To acquaint aeronautical newcomers with problems of design, manufacture, and use of propellers to meet objectives of the Air Force, Navy, and CAA.

(b) To summarize and present propeller practices that have been found to be reasonably satisfactory.

(c) To present, where possible, the reasons for current propeller practices so that sound procedures will not be ignored through lack of understanding or employed needlessly and possibly even detrimentally, where inapplicable.

(d) To stress the importance of airworthiness and safety in propellers.

The handbook is an adjunct to specifications in that it is designed to furnish general background from which propeller specifications have emerged; its purpose is not to supplant propeller specifications.

Contents: (1) Introduction. (2) Aerodynamic Design and Propeller Performance. (3) Structural Design of Propellers. (4) Propeller Construction. (5) Propeller Hubs. (6) Propeller Accessories. (7) Ice Control. (8) Propeller Controls. (9) Propeller Installations. (10) Propeller Testing. (11) Propeller Production Inspection. (12) Propeller Maintenance Problems. (13) Propeller Maintenance Tools and Equipment.

STRUCTURES

Sectional Properties of the Circular Fractions; Giving Area, Location of Centroid, Moments of Inertia of Sectors, Segments, Fillets. Monroe Ames. New York, Exposition Press, 1956. 27 pp., diagrs., tables. $5.00.

A handbook of tables for aeronautical, structural, and mechanical engineers, designed to shorten the labor of computation. The author, a structural designer, has computed the values for every 5 deg. of arc for the three figures which can be designated circular fractions, the sector, the segment, and the fillet. These values are given for radius unity, and by the well-known principles of geometry the properties can be found for any radius by multiplying the area by the square of the radius, the centroidal distances by the radius, and the moments of inertia by the fourth power of the radius. Methods are also given by which the properties of the hollow sector can be found.

THERMODYNAMICS

Thermodynamics and Statistical Mechanics. Arnold Sommerfield. Edited by F. Bopp and J. Meixner. Translated by J. Kestin. (Theoretical Physics, Vol. 5.) New York, Academic Press, Inc., 1956. Diagrs. $7.00.

This volume is the last in a series of six devoted to theoretical physics and originally prepared from lectures delivered at the University of Munich. The smallest possible number of axioms have been employed in presenting this critical examination of a classical science. Statistical mechanics is introduced insofar as possible with elementary methods. Problems directly related to each chapter, with hints to their solution, have been provided.

Contents: (1) Thermodynamics, General Considerations. (2) The Application of Thermodynamics to Special Systems. (3) The Elementary Kinetic Theory of Gases. (4) General Statistical Mechanics: Combinatorial Method. (5) Outline of an Exact Kinetic Theory of Gases. Problems. Index.

Principles of Engineering Heat Transfer. Warren H. Giedt. Princeton, N.J., D. Van Nostrand Company, Inc., 1957. 372 pp., illus., diagrs., tables. $8.20.

The treatment of the subject in the basic, fundamental exposition of the principles of engineering heat transfer is based upon a background in physics, mathematics, and thermodynamics which has been acquired by the average junior engineering student. Although the methods of presentation stress a physical interpretation of the many quantities and processes, extensive analytical material is also included. Special attention has been given to the derivation and explanation of numerous dimensionless parameters and theoretical and semiempirical equations, and much of the material on fluid flow is presented as preparation for the study of convection. The author is Associate Professor of Mechanical Engineering, University of California, Berkeley.

Contents: (1) The Transfer of Energy. (2) The Fourier Conduction Equation. (3) One-Dimensional Steady-State Conduction. (4) Two-Dimensional Steady-State Conduction. (5) Ideal Fluid Flow. (6) Viscous Fluid Flow. (7) Laminar Flow Convective Heat Transfer. (8) Turbulent Flow Convective Heat Transfer. (9) Heat Transfer Outside Tubes and in High-Velocity Flow. (10) Natural Convection Heat Transfer. (11) Condensation and Boiling Heat Transfer. (12) Thermal Radiation. (13) Radiation Heat Transfer. (14) Transient and Periodic Heat Transfer. (15) Transient Temperature Variation in Solids. (16) Heat Exchangers. Symbols and Units. Appendix. Index.

VIBRATION

The Theory of Vibrations for Engineers. E. B. Cole. 3d Rev. Ed. New York, The Macmillan Company, 1957. 362 pp., illus., diagrs., tables. $6.00.

An almost entirely rewritten edition of a work that last appeared in 1950. The book is intended to serve as a gap between an elementary treatment of the subject and the highly specialized, mathematical treatises that have appeared in recent years. Much of the material contained in this text has been employed by the author in teaching his courses at the University of Liverpool where he is Senior Lecturer in Mechanical Engineering. Only the most elementary knowledge of calculus is necessary for proper appreciation of the text, and full explanations are given for all advanced mathematical processes.

Contents: (1) Simple Harmonic Motion. (2) Natural Vibrations of Systems Having One Degree of Freedom. (3) Natural Vibrations of Systems Having Several Degrees of Freedom. (4) Damped Vibrations. (5) Natural Vibrations of Heavy Shafts. (6) Forced Vibrations. (7) Forced Vibrations of Multiple Systems. (8) Some Practical Applications. (9) Engine Vibration. (10) Elimination and Absorption of Vibration. (11) Dynamic Loads. Waves. (12) Transverse Vibration of Beams. (13) The Whirling of Shafts. (14) Self-Induced Vibrations. Appendixes. Miscellaneous Examples.

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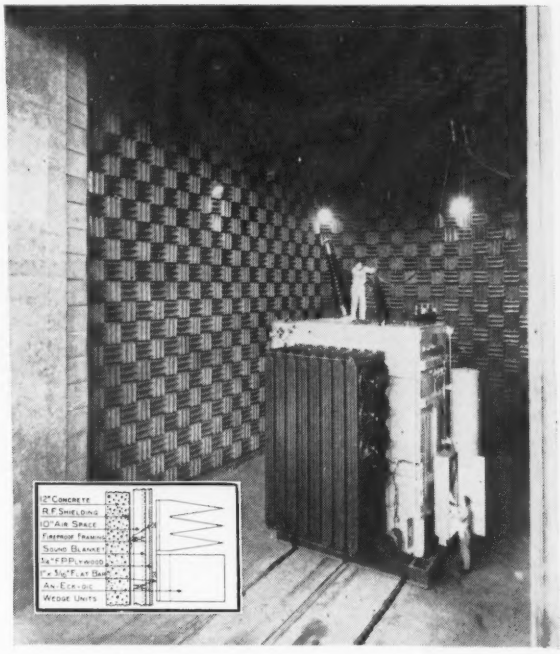

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Engineers—The Navy Department, Bureau of Aeronautics General Representative, Western District, has positions available for aeronautical and electronic engineers in the Los Angeles area at grades GS-12 ($7,570) and GS-11 ($7,035). Persons in these positions deal with industry engineers in the research, development, design, installation, operation, and evaluation of Naval aircraft and major components. Minimum qualifications: B.S. degree in the appropriate or related field of engineering plus 2½ to 4 years of professional engineering experience in the aeronautical field depending on the grade. Interested individuals are invited to write for information or send résumé to Bureau of Aeronautics General Representative, Western District, Room 702, 1206 S. Santee St., Los Angeles 15.

The number preceding the notice represents the Box Number of the Institute of the Aeronautical Sciences to which inquiries should be addressed.

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Engineers—The Air Technical Intelligence Center has reported immediate openings for petroleum fuels and lubricants engineers at salaries to $8,990 per annum. The positions stress the ability to evaluate petroleum refining processes; to construct flow charts and material balances. The applicant must be familiar with the chemistry of petroleum processes, as well as the construction and design of refinery facilities. Those with knowledge of foreign languages will be given additional consideration. Applications should be addressed to Commander, Air Technical Intelligence Center, Attn.: AFOIN-4X2b, Wright-Patterson AFB, Ohio.

Aeronautical and Mechanical Engineers and Electronic Scientists—The Flight Test Division of the Naval Air Test Center has openings for aeronautical and mechanical engineers at Grades GS-5 to GS-12, salaries from $4,480 to $7,570 per annum, and electronic scientists at grades GS-5 to GS-11, salaries from $4,480 to $7,035 per annum. The Flight Test Division is engaged in the evaluation of new Navy fighter aircraft, high-speed flying boats, and all types of helicopters. Work includes performance, stability and control, carrier suitability, and hydrodynamics. The incorporation of automatic data-handling systems and telemetering techniques has increased the divisional needs for electronic engineers. The work is closely associated with the aircraft development work of the majority of the major aircraft manufacturers of the country. Visits to major air installations throughout the country are a routine part of this engineering work, and tests are conducted regularly aboard the Navy's newest aircraft carriers. Opportunity exists for both the experienced engineers and the recent graduates. In several positions, piloting background is desirable. Send a résumé to the Chief Engineer, Flight Test Division, Naval Air Test Center, Patuxent River, Md.

Engineers—The Army Transportation Research and Engineering Command has openings for aeronautical research and development engineers for supervision and management of programs in the fields of STOL/VTOL aircraft and helicopters. Specialty fields include aerodynamics, rotary wing, stability and control, structures, power plants, and propellers. These positions include GS-11 through GS-14 grades,

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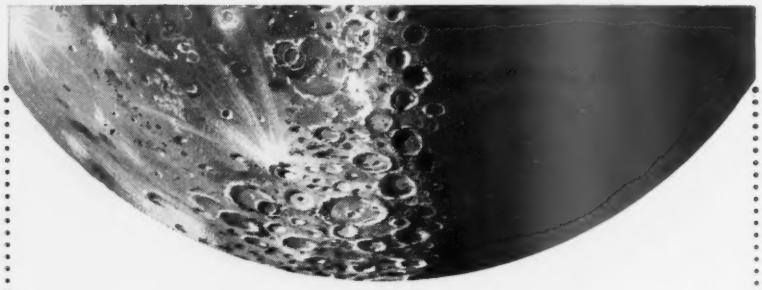

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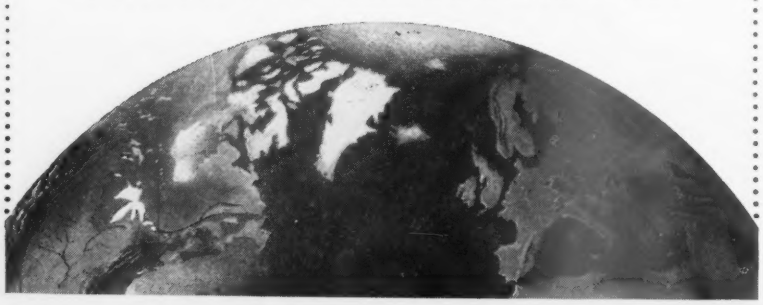

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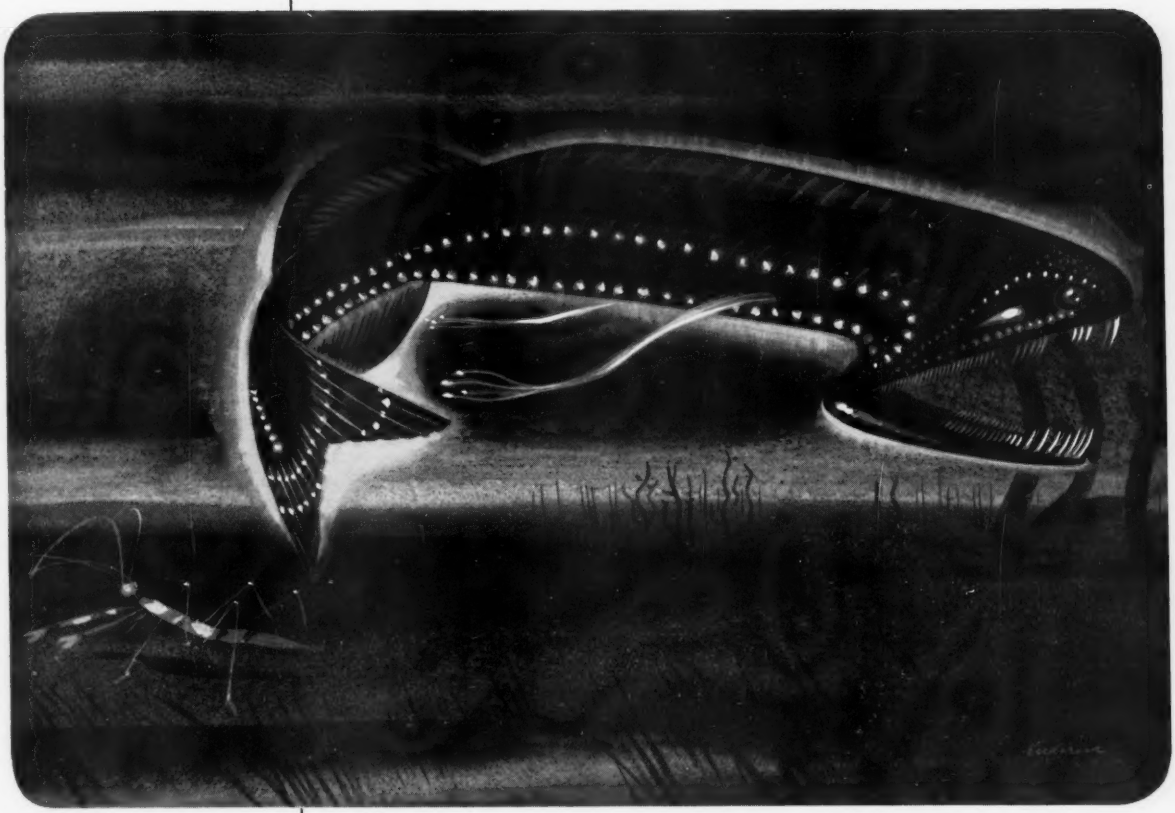

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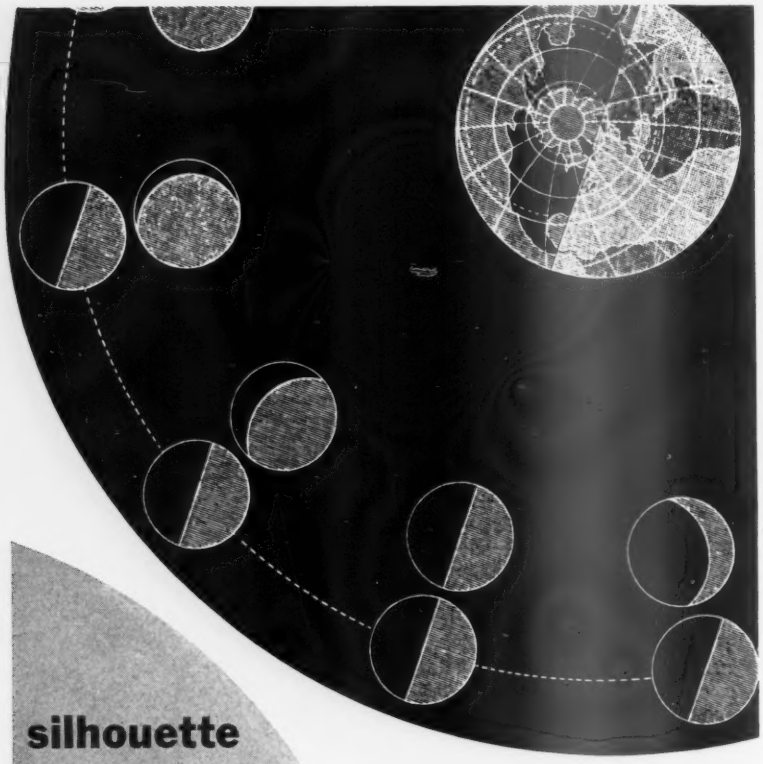

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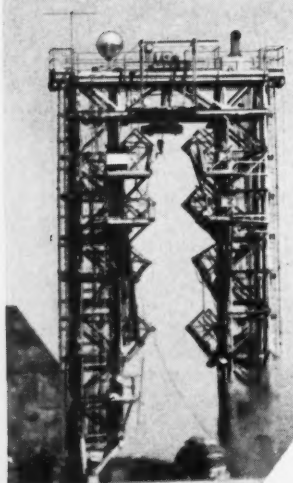

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(Continued from page 104)

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Held, Fred H., Jr., B.S. in Ae.E., Engr., McDonnell Aircraft Corp.

Helgesen, John O., B. of Ae.E., Research Engr., Grumman Aircraft Engineering Corp.

Henderson, Timothy C., B.S. in Ae.E., 2nd Lt., U.S. Marine Corps.

Janoyan, Hagop A., B.S. in Ae.E., Student, Wayne Univ.

Johnson, Oliver W., Test Engr., Ordnance Div., Minneapolis-Honeywell Regulator Co.

Jones, Gary R., Assoc. Engr., Convair Div. (Pomona), General Dynamics Corp.

Kahan, Alfred, B. of Ae.E., Aero. Engr., Wright Aeronautical Div., Curtiss-Wright Corp.

Kenney, Jack W., B.S. in Ae.E., Assoc. Engr., Lockheed Aircraft Corp. (Van Nuys).

Mayo, Edward E., Aero. Engr., NACA (Langley Field).

Melnik, Robert E., B. of Ae.E., Research Engr., Grumman Aircraft Engineering Corp.

Molloy, Thomas F., B.S. in Ae.E., Design Trainee, Grumman Aircraft Engineering Corp.

Rakich, John V., B.S., Aerodynamicist, Propulsion Research Corp.

Seeney, Paul J., B.S. in Ae.E., Assoc. Engr., McDonnell Aircraft Corp.

Sherman, Irving R., B.S. in Ae.E., Aero. Research Engr., NACA (Langley Field).

Timm, James D., Assoc. Engr., Convair Div. (Pomona), General Dynamics Corp.

Vernon, Robert M., B.S. in M.E., Assoc. Aerodynamics Engr., Convair Div. (San Diego), General Dynamics Corp.

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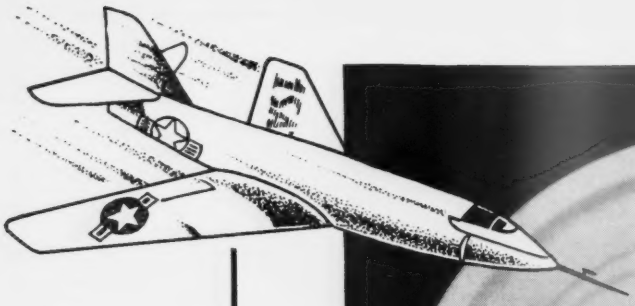

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"Variac" Motor Speed Controls. Bulletin. *General Radio Company*, 275 Massachusetts Ave., Cambridge 39, Mass. *See page 111*

Aircraft and Jet-Engine Fabrication. Facilities booklet. *A. O. Smith Corp.*, Milwaukee 1. *See page 22*

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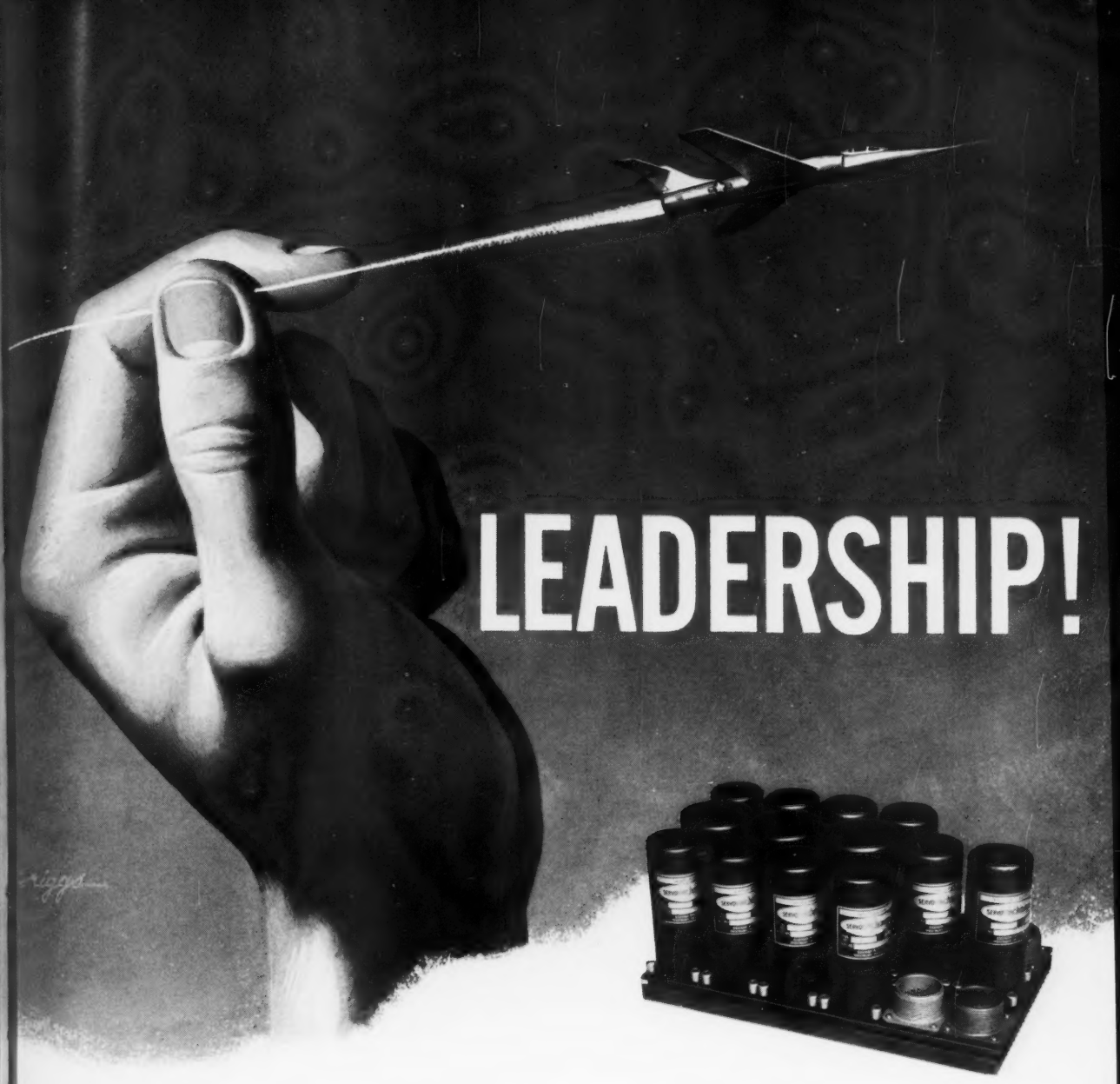

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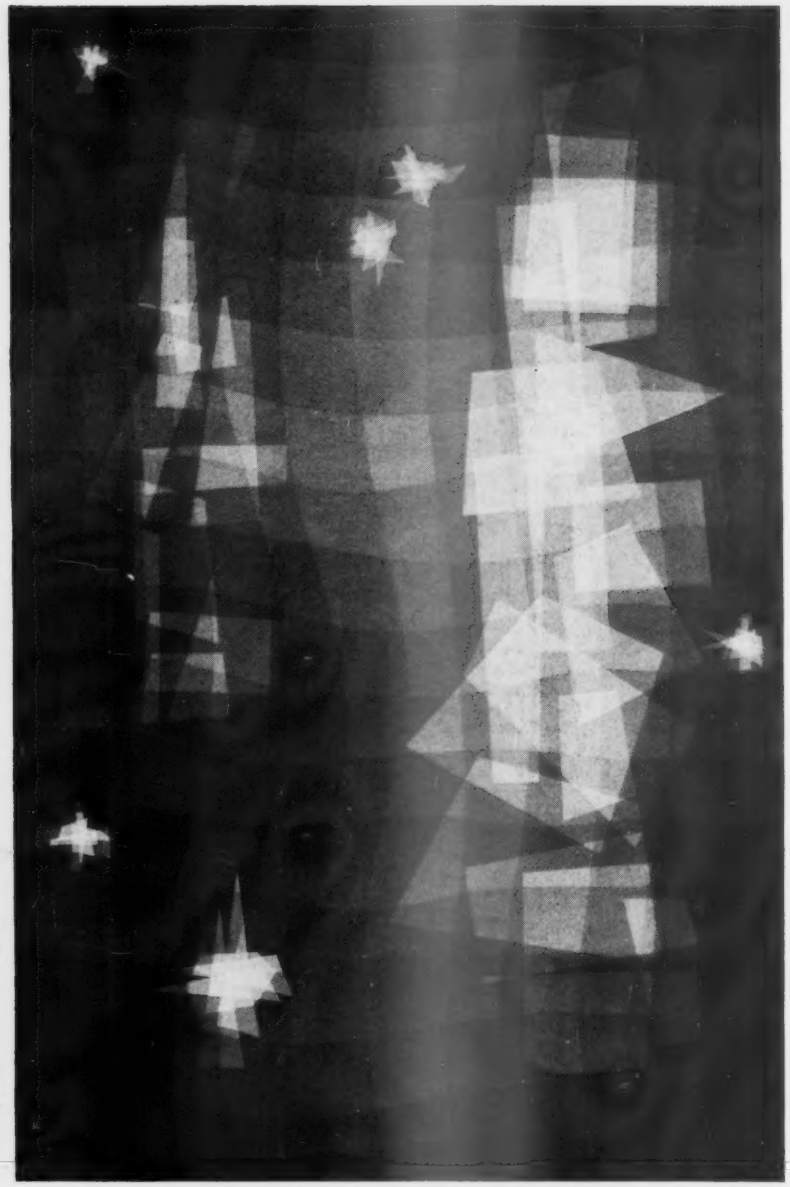

"ARCTIC STARS," latest in a series of paintings by Simpson-Middleman, painters of the meanings of science. They describe this interpretation as "an expression of entropy in the cosmos. Starlight, clear and cold, contrasts with the warm color of autumn leaves. Behind both, the undulating field of the celestial wall." Painting courtesy of John Heller Gallery Inc.

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